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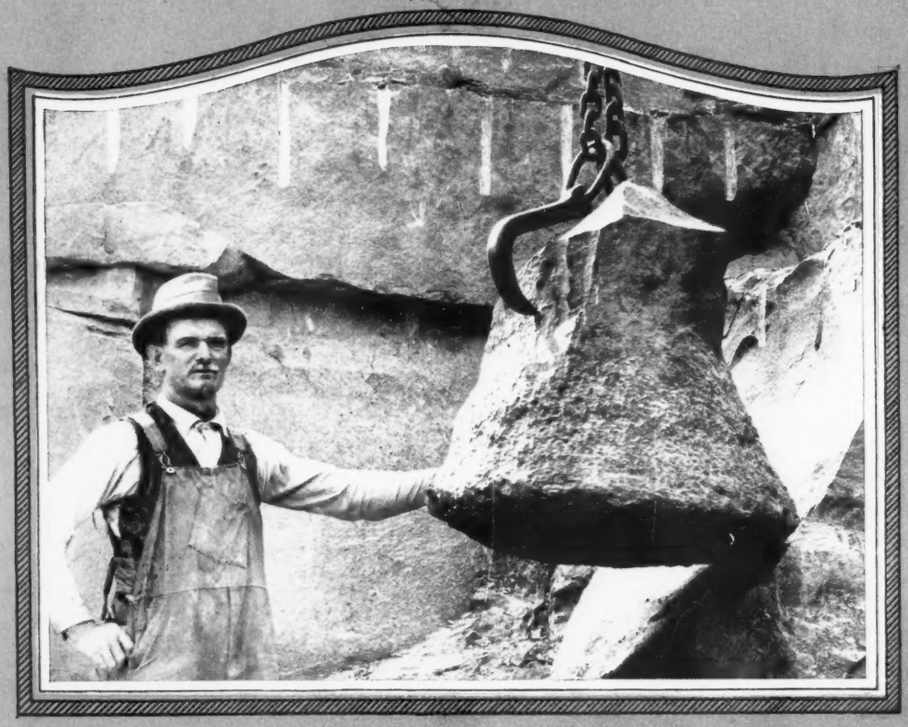

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Extracting Gaseous Riches from the Atmosphere
Wilkinson Stark

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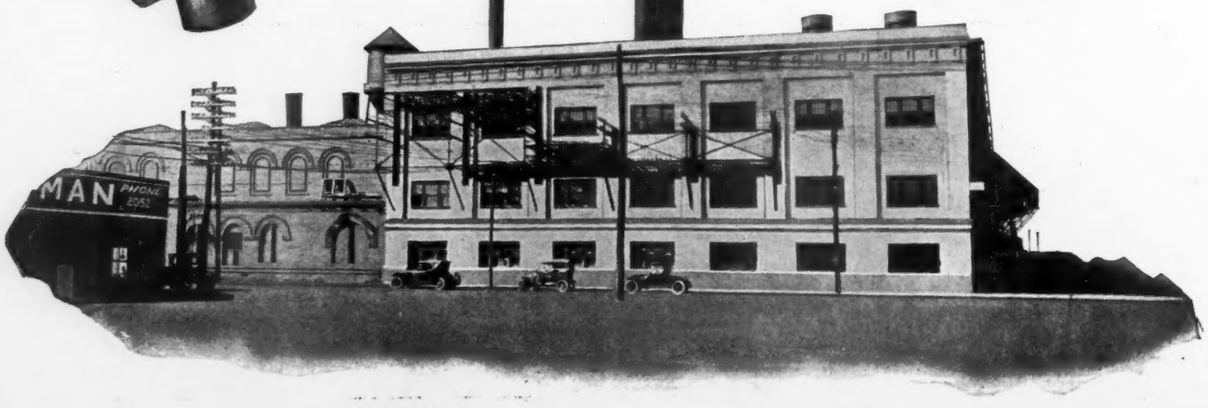

As a matter of reciprocal business courtesy help trace results

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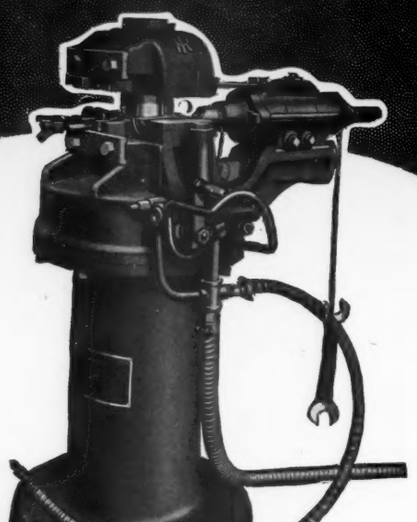

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Mining The Air

Extracting Gaseous Riches for Various Industrial Purposes From Our Enveloping Atmosphere

BY WILKINSON STARK

MINING the air is a picturesque term that has been applied to the extraction of "gaseous ores" from the atmosphere surrounding the earth's surface. Strictly speaking, the air we breathe is a mechanical mixture of a number of gases; and it is because these gases are mechanically mixed and not chemically combined that it is practicable for us to commercially effect their separation or extraction in order that they can be utilized for different purposes. Before this article is finished, the reader will realize how big a part the compressor plays in this comparatively new field of human endeavor.

To the layman, it may be well to explain that the elementary gases which enter into the composition of the atmosphere are eight in number—so far as present knowledge discloses, and are of the following proportions: nitrogen, 78 per cent.; oxygen, 21 per cent.; and the remaining 1 per cent., by volume, consists of argon, neon, krypton, xenon, hydrogen, and helium. The combination of these several gases is densest at the surface of the earth, and thence skyward the gaseous envelope gradually becomes rarefied. At an elevation of three and a half miles, so the physicist tells us, the density of the air is reduced to one-half that at sea level. It is owing to the depletion of the oxygen in the air as the mountain climber or the aviator ascends that breathing becomes more and more difficult; and at great altitudes it is therefore necessary for the flier or the explorer to make up for this deficiency by drawing pure oxygen from tanks in which it is held under pressure.

The air-products industry, which is commercially concerned with the extraction of the gaseous ores of the atmosphere, is a relatively newcomer in our busy life, and its development has followed closely the perfecting of apparatus for the compressing and the refrigerating of air until the latter is converted to a liquid state. After the air is liquefied, the various elements composing it may be separated from one another because each has its own evaporation point. In short, separation is, in effect, a process of distillation and not radically unlike the well-known methods employed in bringing about the separation of alcohol from water.

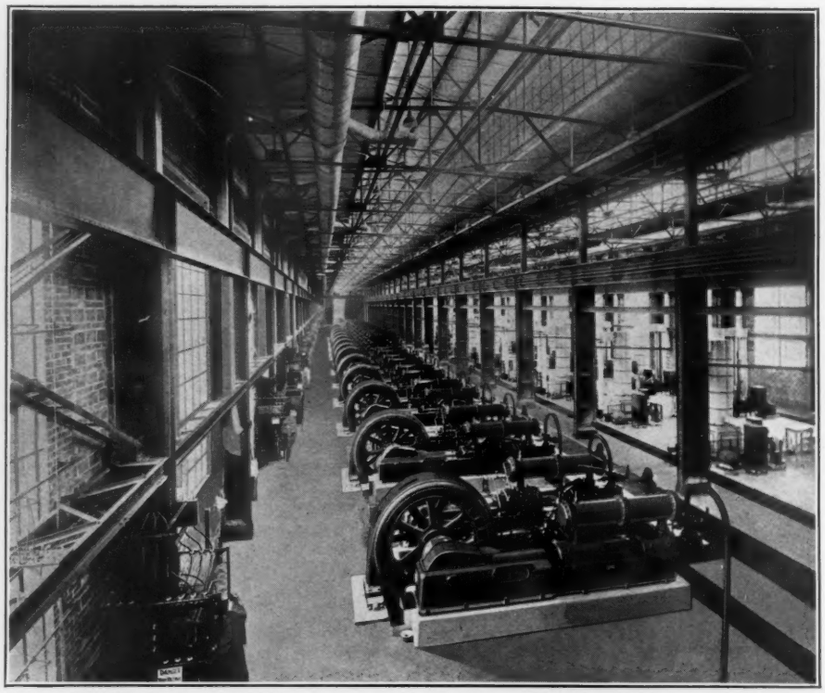
THE popular conception of the atmosphere is that it is a gaseous medium which is primarily designed by Nature to sustain and to promote animal and vegetal life of all sorts through the inhaling and the exhaling processes peculiar to the plant or the creature immediately concerned.

Only a comparatively few of us, and these principally chemists, are aware that the free air can be made to serve still other purposes by isolating one or more of the atmosphere's constituents and by putting them to special uses. The accompanying story sketches broadly what gases compose the atmosphere, how they can be separated from one another by means that have been developed for that purpose, and to what ends they can then be applied in industry for the common good.

Of the different gases composing the atmosphere in proximity to the earth, oxygen is the most important in an industrial sense. Perhaps 99 per cent. of the oxygen recovered from the air is now used in welding and in cutting by means of the oxy-acetylene torch. Because of the intense heat generated in burning these gases together—that is, a temperature of 6,332°F., steel and iron can be cut or welded readily and quickly. The public is so familiar with the various applications of the oxy-acetylene torch that it is quite unnecessary to enumerate them here. Day by day, new applications of this source of intense and directed heat are being devised, and the demand for gaseous oxygen is growing in proportion.

Inasmuch as this Magazine has recently described in some detail the facilities and the processes by which liquid oxygen can be manufactured from the free air, it is not desirable to go over the same ground in the present article. As will be recalled, the air is compressed initially to a pressure ranging from 600 to 3,000 pounds to the square inch—depending upon the system employed—and is then allowed to expand through a nozzle or by doing work in an engine so that the drop in temperature due to this expansion will initiate and continue a cumulative refrigerating action. When a proper degree of cold is thus attained the air passes from the gaseous to a liquid state. While the air as a whole is liquefied in this manner, certain of its components tend to return more quickly to the gaseous state than others; and nitrogen, because it vaporizes at a lower temperature than does oxygen, will boil off from the liquid air and leave the oxygen still in a liquid state. Liquid oxygen, produced in this manner, is today an industrial explosive; and the same liquid oxygen when allowed to vaporize and to become gaseous again is the oxygen which is so extensively used in cutting or welding metals.

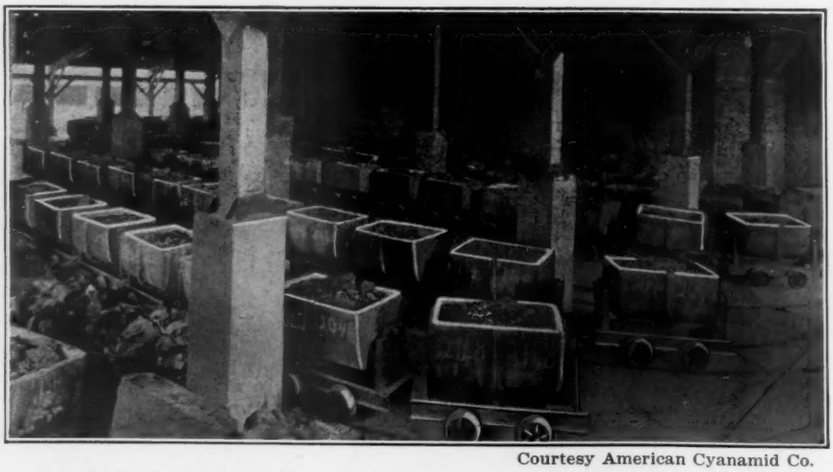
Nitrogen and argon have come into rather wide application for filling incandescent lamps. Until recently, the common practice in lamp making was to create a low-pressure or partial vacuum in the bulb which, of course, was necessary to prevent the oxidation of the filament. With the perfection of the tungsten filament and the development of the inert-gas-filled lamp it became possible to produce a greater intensity of light with a given amount of electric power. Recently, it has been suggested that nitrogen be used in the canning industry to displace oxygen from the container



Class "XRE" direct-connected, electric-motor-driven compressors at Muscle Shoals, Ala.

Courtesy American Cyanamid Co.

A battery of furnaces in which ground calcium carbide is heated to promote its absorption of gaseous nitrogen.



Courtesy American Cyanamid Co.

Carloads of calcium carbide which has come directly from the electric furnace.

at the time of sealing. Nitrogen, because of its inertness, does not form injurious compounds or combinations, and it is believed by some experimenters that the nitrogen would, therefore, keep the foodstuffs fresher than would be the case if oxygen were present.

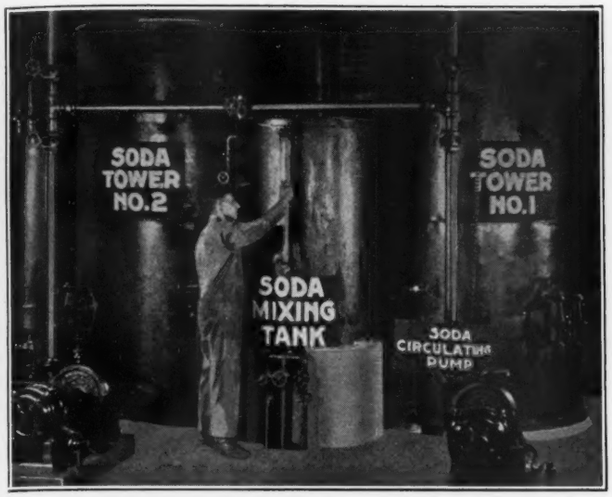
Neon is one of the very rare gases found in the air. It requires 55,000 volumes of air to extract one volume of neon. It has recently been employed industrially as an electric-current indicator because of its acute sensibility to electricity. In the presence of an electric current it glows a deep orange color and, enclosed in a small glass tube, it is used to indicate if the spark plugs of the cylinders of gasoline engines are functioning properly. By placing the tube against the spark plug while the engine is running, it immediately registers the condition of the spark plug whose circuit has been interrupted. It also has an application in incandescent lamps used as signs. The filament of the lamp, in this case, is fashioned into a letter or a word and is made of a special composition steel. It gives off a deep orange glow; and, of course, any number of words may be arranged.

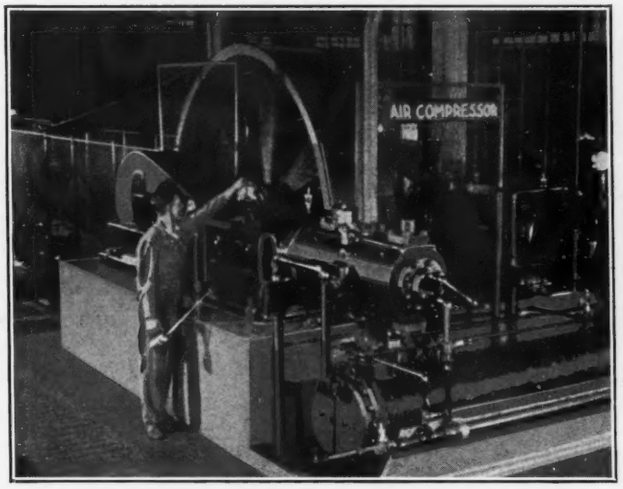
Helium, another of the rare gases in the atmosphere, is more economically recovered from natural gas as it is found in some parts of the country, particularly near Forth Worth, Tex. The air services of both the United States Army and the Navy are especially interested in this gas for inflating dirigibles. Its atomic weight is 4 while that of hydrogen is 1, hydrogen being the lightest substance known. Helium has the highly important quality of being non-inflammable, and in this respect differs from hydrogen which is highly inflammable and burns with explosive intensity, forming water vapor with the oxygen of the air. While helium is four times as heavy as hydrogen it is only one-fourth as heavy as oxygen and two-sevenths as heavy as nitrogen, so that a balloon inflated with it ascends readily.

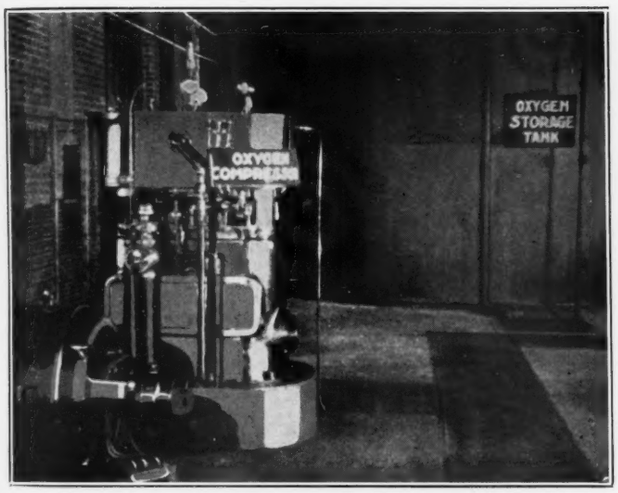
A sum of $30,000,000 is probably invested in plants in the United States alone which are engaged in the manufacture of air products to be used directly for industrial purposes. The annual gross sales of these companies amount to approximately $14,000,000.

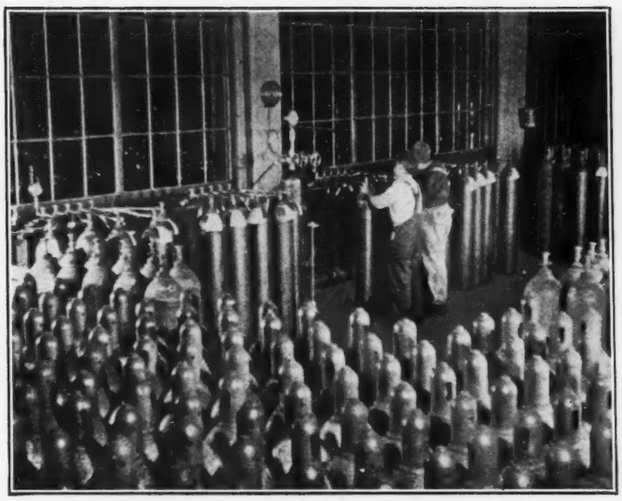
So far this article has dealt with the application of these gases of the atmosphere in their chemically uncombined state. Now let us take up the fixation of nitrogen with other elements to make various compounds which are of great importance in the industrial field. While nitrogen in its natural state is a gas, it forms chemical compounds with other elements—sometimes in the shape of a liquid, as in nitric acid; again as a solid, as in nitrate of soda; and at other times as a gas, as in ammonia. The uses of nitrogen in the gaseous state are very limited; but nitrogen chemically combined is one of the most important of the elements in the universe, so far as we know. It is estimated that there are 30,000 tons of nitrogen gas in the atmosphere over each acre of the earth's surface. The trick is to combine this nitrogen in a form in which it can be utilized in the industrial arts and in agriculture. The fixation of nitrogen

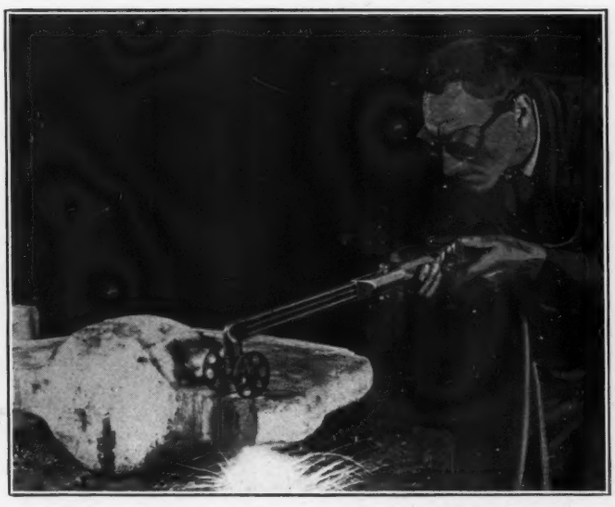
PHASES IN THE MANUFACTURE AND THE USE OF OXYGEN







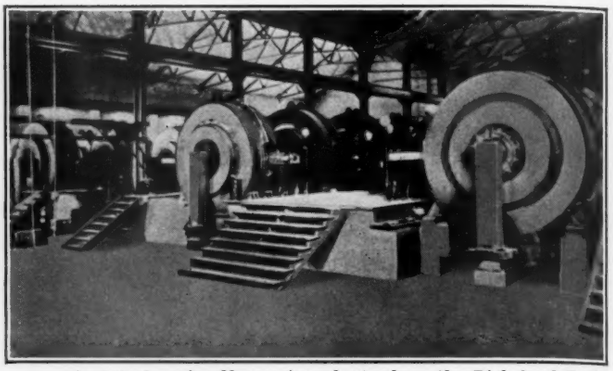




Courtesy Air Reduction Co.

Atmospheric air must first be freed of carbonic acid gas by passing it through soda towers. The cleansed air is then ready to be subjected to compression to carry out its liquefaction. Gaseous oxygen is separated from the liquid air by allowing the nitrogen to vaporize, after which the remaining oxygen is compressed and stored in tanks for use. The gaseous oxygen, when mixed with acetylene, produces an intensely hot flame which is capable of cutting metals.

Rjukan, Norway, one year after the establishment of an air-nitrogen plant. Before that the valley was a rocky waste.



An interior of a Norwegian plant where the Birkeland-Eyde process is employed for the fixation of atmospheric nitrogen.

is one of the vital questions before the scientific and the economic world today.

Nitric acid is one of the most important of all the manufactured chemical compounds. It is composed of nitrogen, hydrogen, and oxygen in certain proportions, and forms the basis of all nitroexplosives. These include guncotton and smokeless powder, which are known as trinitrocellulose, picric acid or trinitrophenol, T. N. T. or trinitrotoluol, trinitroanaline, and various other compounds. It is also necessary in the manufacture of celluloid in its various forms, artificial leather, lacquers, and many other materials used extensively in industry.

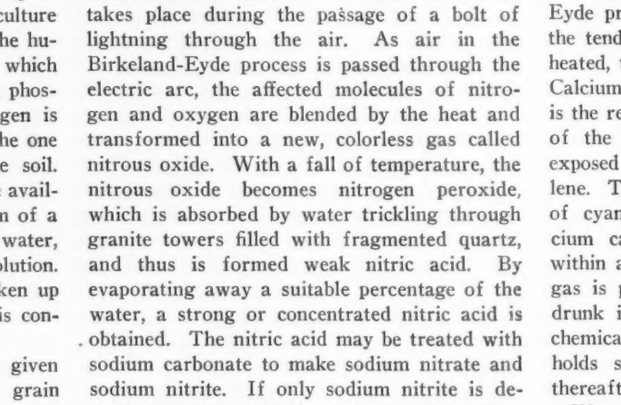
In agriculture, nitrogen is even more important than in the industrial arts, for agriculture is fundamental to the very existence of the human race. There are three elements in which most soils are deficient, namely, nitrogen, phosphorus, and potassium. Of these nitrogen is the most essential, the most costly, and the one which is most readily exhausted in the soil. It is necessary to plant growth; but to be available to the plant it has to be in the form of a solid which, in turn, must be soluble in water, as all plants take up nourishment in solution. Carbon dioxide, on the other hand, is taken up by the leaves from the air in which it is contained to a small extent.

It is estimated by those who have given careful study to the subject that the grain crops of the United States alone exhaust 2,250,000 tons of nitrogen in the soil each year. Only about 10 per cent. of this is returned to the soil in the form of fertilizer, leaving a yearly deficiency of about 2,000,000 tons. This depletion cannot go on indefinitely without the soil productivity falling to the point where the food demand will be greater than the supply. The only natural nitrogen deposits in the world are in Chile, where the substance exists in the form of nitrate of soda. These fields will not last more than a few generations at the present rate of consumption. In 1920, something like 3,000,000 tons of nitrate of soda were exported from Chile, of which amount the United States took 1,430,000 tons. The only alternative is to perfect processes for the utilization of the inexhaustible quantities of nitrogen in the air.

What are the processes by which man can, at will, provide sufficient fixed nitrogen to meet his vital needs? Prior to twenty-odd years ago, the only recognized commercial means for the recovery of free nitrogen on a promising scale was through its reclamation from the gases of by-product coke ovens. As this is not, to be exact, an extraction of gaseous nitrogen from the air we shall not deal with the process here.

The first really successful procedure developed for the fixation of atmospheric nitrogen was the so-called arc process, devised conjointly by two Scandinavians, Messrs. Birkeland and Eyde. The basic principle of this process consists in chemically uniting the free and uncombined nitrogen and oxygen of the air by means of an electric arc having a temperature of 6,000°F. It is just this which takes place during the passage of a bolt of lightning through the air. As air in the Birkeland-Eyde process is passed through the electric arc, the affected molecules of nitrogen and oxygen are blended by the heat and transformed into a new, colorless gas called nitrous oxide. With a fall of temperature, the nitrous oxide becomes nitrogen peroxide, which is absorbed by water trickling through granite towers filled with fragmented quartz, and thus is formed weak nitric acid. By evaporating away a suitable percentage of the water, a strong or concentrated nitric acid is obtained. The nitric acid may be treated with sodium carbonate to make sodium nitrate and sodium nitrite. If only sodium nitrite is desired the nitric acid is acted upon by sodium hydroxide.

Again, if calcium nitrate is the objective, then nitric acid and limestone are brought together to effect the needful reaction. Calcium nitrate is largely used as a fertilizer. The arc process is not commercially practicable except in countries where hydro-electric power makes an abundance of cheap current available. This explains why Norway has been singularly successful in the employment of the Birkeland-Eyde process; and the adoption of this method for the fixation of atmospheric nitrogen has transformed previously barren and unproductive parts of Norway into bustling communities. The output capacity of arc-process plants throughout the world in 1920 was 290,000 long tons, valued, on a basis of 13 per cent. nitrogen, at $11,600,000—that is, at the rate of $40 a ton.

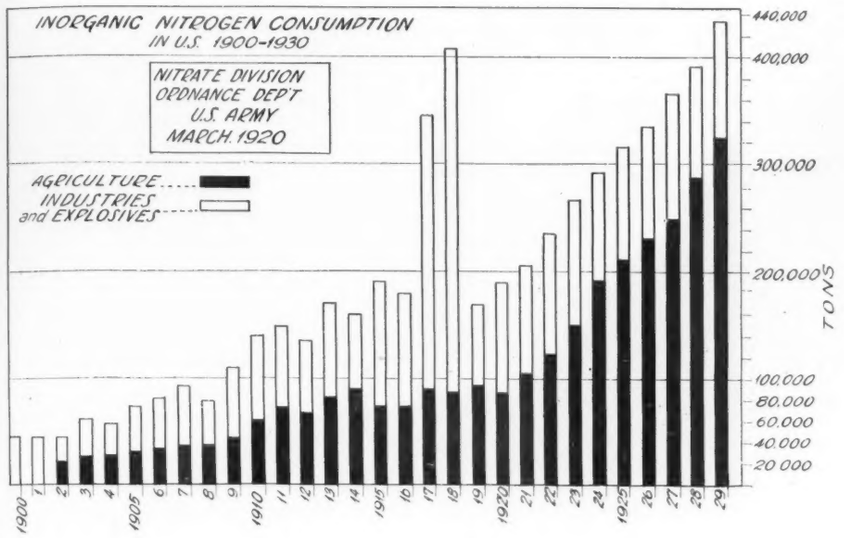


Where lime and coal are fused in the electric furnace to produce calcium carbide. A step in the fixation of atmospheric nitrogen.

The cyanamid process, which has obtained a prominent position in the fixed-nitrogen industry, was conceived after the Birkeland-Eyde process was invented, and is based upon the tendency which calcium carbide has, when heated, to absorb and to hold gaseous nitrogen. Calcium carbide, as most of us are aware, is the result of fusing coal and lime in the heat of the electric arc. Calcium carbide, when exposed to water or moisture, gives off acetylene. The procedure followed in the production of cyanamid consists in heating ground calcium carbide to a temperature of 1,832°F. within an electric oven through which nitrogen gas is passed. After the calcium carbide has drunk its fill of the gas the carbide becomes chemically known as calcium cyanamid and holds substantially 20 per cent. of nitrogen thereafter.

We might point out here that the gaseous nitrogen needed in the cyanamid process is obtained from the atmosphere by liquefying the air and capturing the nitrogen which is separated from the oxygen by distillation or vaporization. To liquefy the air, compressors are required, as we have previously described. Cyanamid is used largely and principally in the artificial fertilizer industry. It is possible, by treating cyanamid with steam under pressure, to produce ammonia which, in turn, can be converted into nitric acid, ammonium nitrate, ammonium sulphate, cyanides which are employed in the mining industry, hydrocyanic acid—an effective fumigant, and many other nitrogenous chemical compounds.

There is one large cyanamid plant in Canada, at Niagara Falls, which has a capacity of 80,000 tons of cyanamid annually, representing a total value of $4,800,000. The United States Government erected at Muscle Shoals, Ala., in 1918, the largest



cyanamid plant in the world, which, if run to capacity, would be able to turn out 120,000 tons in the course of a year. This plant is now idle awaiting the decision of the Federal authorities as to its ultimate disposal. The total capacity of cyanamid plants the world over, according to 1920 figures, has been put at 1,770,000 long tons, with a value of $100,000,000.

In conclusion, we shall touch upon a third process for the fixation of atmospheric nitrogen—a process which played a notable part during the World War in supplying the Central Powers with the nitrogen needed for the manufacture of high explosives. The Haber process, for so it is known, depends on the direct union of nitrogen and hydrogen to form ammonia. This union is accomplished by passing a mixture of one volume of nitrogen and three volumes of hydrogen—the chemical constituents of ammonia—over a suitable catalyst. When this is done, the nitrogen and hydrogen are at a pressure of from 100 to 200 atmospheres and heated to approximately 1,000°F. The consequence of the pressure, heat, and contact with the catalyst is the production of ammonia. The nitrogen used is obtained from the air in the manner previously described, and the needful hydrogen is generated either from water gas or by the electrolysis of water. The consequent ammonia may be converted into various nitrogenous compounds.

It is claimed that the Haber process is the cheapest method that has yet reached a commercial stage for the production of ammonia. Dr. Georges Claude has also evolved a process for the manufacture of ammonia by the direct union of nitrogen and hydrogen while under pressure, but his work has not reached an industrial stage comparable with that of the Haber process. According to the statistics available, the total productive capacity of all synthetic ammonia plants three years ago amounted to 1,503,000 tons annually; while the combined potential capacity of all nitrogen-fixation plants the world over at that time was put at 3,570,400 long tons, having an aggregate value of substantially $200,000,000.

THE ANEROID BAROMETER FOR INDICATING ALTITUDES

AT a recent meeting of the British Institution of Mining & Metallurgy, Mr. R. H. L. Lee read an interesting paper describing the uses of the aneroid barometer in practical engineering. The instrument, which was invented by a Frenchman in 1843, is, at least one form of it, simply a delicate spring balance in equilibrium, which measures differences of atmospheric pressure with a great degree of accuracy.

As the pressure of the atmosphere increases or decreases as the altitude changes, the indicating air pressure also gives a record of the altitude, and, accordingly, the aneroid barometer is quite frequently used for altitudes as well. It is not minutely accurate for the latter purpose; but it has a wide practical scope for rapidly determining considerable differences of level, as in aviation.

In good aneroids, the average maximum error varies between 20 and 30 feet. Such errors are small when measuring comparatively large and rapid changes of altitude; but they illustrate the limitations of the aneroid in measuring small differences. Differences in altitude are not directly proportional to differences in pressure; and where the scale of the aneroid is divided into equal divisions for the changing pressures the altitude scale is divided into gradually decreasing spaces as the height increases. The aneroid is quite sensitive to changes of temperature, so that a table of constants is necessary for making corrections in the readings, and this applies to both scales.

AERIAL LIGHTHOUSE AIDS NIGHT FLYING

SERVING as a beacon to aviators flying at night and as an observation tower during the day, the aerial lighthouse, recently built by the United States Bureau of Aeronautics at the Hampton Roads Naval Air Station, is visible twenty miles when viewed by the man in the air from a horizontal position and may be seen for a distance of six miles by a pilot circling immediately above it. The tower is located 65 feet above mean high water.

This lighthouse, built as an aid to night flying, automatically flashes an acetylene light of 4,000 candle power. The flashes, throwing a white light, are each 8/10ths of a second in duration. The period of eclipse lasts for 3 and 2/10th seconds. The rays of light serve the aviator, groping in mid-air after darkness, much in the same way that the lighthouse and the more recent navigational radio stations guide the mariner voyaging in treacherous waters. This aerial lighthouse, however, functions for the greater part of the 24 hours, serving as an observation tower for flight operations during the hours of daylight.

In view of the contemplated expansion of the carriage of postal matter by aircraft, any system of lighting the "airway" of the aviator should be of interest. It is proposed to erect powerful beacons at specified intervals along the routes over which night flying is to be undertaken. Inasmuch as the aerial lighthouse as installed at Hampton Roads is visible for but twenty miles, such a system would require numerous towers placed comparatively close together.

A 4,000-candle-power aerial lighthouse at Hampton Roads, Va. The illuminant is acetylene.

How the 250-Foot Piles for One of the Ventilating Shafts of the Hudson River Vehicular Tunnel were Driven

By FRANK W. SKINNER and S. G. ROBERTS

IN PREVIOUS issues, this Magazine has covered comprehensively the ventilating problem associated with the design of the Hudson River Vehicular Tunnel, and it has gone to some length to explain just how it is proposed to insure an ample circulation of fresh air from end to end of each of the big traffic tubes.

As will be recalled, the final plans provide for the construction of one double and six single or independent shafts. Four of these shafts are linked with the two tubes at points inland from the bulkhead lines, while the double shaft on the Manhattan side of the river and two of the single shafts on the opposite side of the waterway will be situated close to their respective pierhead lines. In other words, the junctions between these offshore ventilating shafts and the twin tunnels will be made below the river bed. This, in itself, would not present notable difficulties if certain natural conditions did not exist that occasion doubt as to the stability or the supporting capacity of the silt in which the offshore shafts on the New Jersey side must rest.

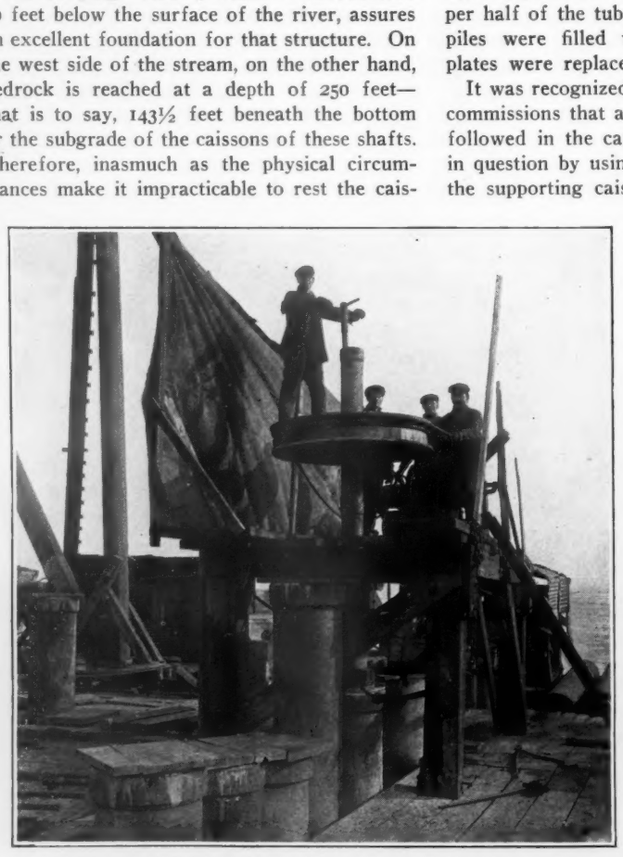
In the case of the double New York shaft, the underlying bedrock, which is encountered 70 feet below the surface of the river, assures an excellent foundation for that structure. On the west side of the stream, on the other hand, bedrock is reached at a depth of 250 feet—that is to say, 143½ feet beneath the bottom or the subgrade of the caissons of these shafts. Therefore, inasmuch as the physical circumstances make it impracticable to rest the caissons directly on the rock, it has been necessary to devise means by which the dead weight of the shafts and the connecting tunnels could be supported by the ledge. This should be plain in view of the fact that each completed shaft will weigh substantially 10,155 tons.

Accordingly, the engineers of the Bridge and Tunnel Commissions decided to transfer the loads of the shafts to bedrock by means of groups of piles made up of steel casings, 24 inches in diameter, filled with reinforced concrete. Fundamentally, this decision involved nothing new in engineering practice, because this very thing was done in the case of one of the rapid-transit tubes built under the East River. The supporting piles for that tunnel were driven in this wise: Some of the bottom plates were removed from the tube, and the working section was bulkheaded at each end so as to form a chamber which could be filled with air at a pressure suited to the outlying hydrostatic head. Then, in convenient unit lengths, the tubular piles were assembled within this chamber and forced downward to bedrock by jacks reacting against the roof or upper half of the tube. Afterwards, when these piles were filled with concrete, the bottom plates were replaced.

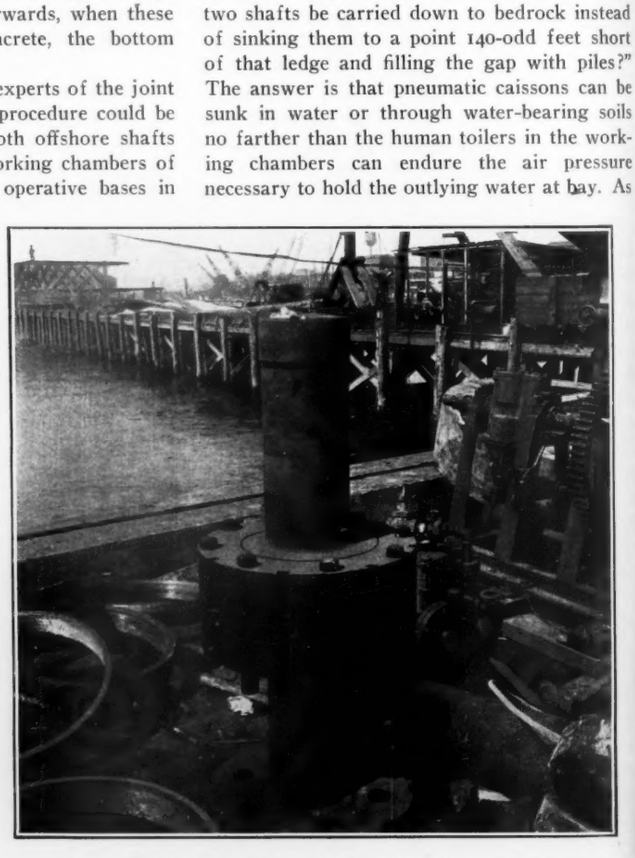
It was recognized by the experts of the joint commissions that a similar procedure could be followed in the cases of both offshore shafts in question by using the working chambers of the supporting caissons as operative bases in sinking or forcing tubular steel piles downward to the ledge rock. However, it was apparent that such a course would entail very heavy outlays and, perhaps, rather protracted work. Therefore, the contract merely specified what conditions must be satisfied and left it to the contractor to adopt any method which would produce acceptable results.

Mr. Clifford M. Holland, Chief Engineer of the Tunnel Commissions, is outspoken in his commendation of the initiative and the resourcefulness shown by the contractor, Booth & Flinn, Ltd., and the subcontractor, Sprague & Henwood. As he expresses it, "This job of pile sinking is the finest example of coöperation I have ever encountered between the designing engineers and the contractors, and the outcome to date is one in which everybody concerned may feel justified pride. It is proof of what unexpected things may be achieved by the adaptation of facilities intended primarily for a radically different field of service."

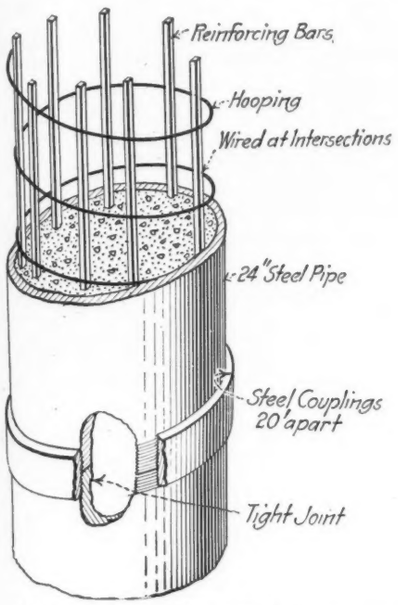
There may be persons unacquainted with subaqueous foundation work who are prompted to ask: "Why couldn't the caissons for these two shafts be carried down to bedrock instead of sinking them to a point 140-odd feet short of that ledge and filling the gap with piles?" The answer is that pneumatic caissons can be sunk in water or through water-bearing soils no farther than the human toilers in the working chambers can endure the air pressure necessary to hold the outlying water at bay. As



After each pile has been secured to the rocky ledge more than 200 feet below the surface of the river it is necessary to cut off the pile where it will join the under side of the ventilating shaft. This work is done by a special rotary cutter, the upper end of which is pictured here.



A close-up of the special internal pipe cutter devised to cut off the surplus portion of each pile at Elevation 195. The cutter consists of a rotating head carrying a number of radially disposed cutting dies which are fed outward and score a channel through the wall of the enveloping tube.



Details of a pipe joint and of the system of reinforcing placed within the concrete-filled piles that are sunk to bed rock.

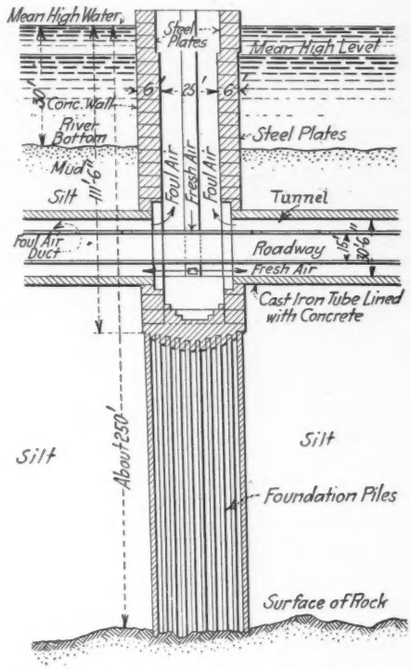
a broad proposition, sand-hogs are incapable of doing useful work for any effective period of time when subjected to an air pressure above 50 pounds—that is, about 115 feet below the surface of the water. The problem in the present instance calls for a submergence of more than double this.

Under the circumstances, it was evident that piles would have to be utilized to anchor the caissons securely in position so that there would be no subsidence when the substructure of each ventilating shaft had reached the predetermined point in the path of the vehicular tube that would subsequently be joined with it. As will be seen, the plan called for the driving, in advance of the sinking of the shafts, of two groups of hollow steel piles of sufficient length to extend, before cutting off, from a few feet above water down and into the rock far enough to insure a firm footing. Each group will be composed of 42 piles; and one of these aggregations has already been placed. These driven piles have been cut off under water at the level at which the bottom of the associate caisson will rest. In other words, the present tops of these piles will be embedded in the concrete which will fill the working chamber of the caisson, when the sinking is completed, and thus bind the caisson to the sustaining concrete-filled metal columns.

Preliminary to the driving of any of the hollow steel piles, a falsework of wooden piles was driven around the site of the north ventilating shaft, where operations were first taken in hand. On these piles was built a working platform about six feet above mean high water, and this platform was stiffened by steel girders for the purpose of insuring a rigid base for the exact placing of the 42 piles and, later, for the guidance of the shaft caisson during sinking. The piles are made up of a series of 20-foot lengths, threaded on the outside at adjacent ends and coupled by external sleeves which have made it possible to bring neighboring pipe ends snugly together and to form tight joints. At first, the specifications required that each of these joints should be able to withstand, without leaking, a shop-test pressure of 500 pounds; but this involved some assembling difficulties, and the test pressure was, therefore, reduced to 150 pounds per square inch. This is believed ample to insure satisfactory strength and accuracy of alignment.

Each 20-foot pile unit weighs about 3,100 pounds, and three of these were coupled together to form a starting length of 60 feet. At the bottom of the lowermost section a reinforcing ring was screwed on to serve as a cutting edge, for it will be recognized that each hollow pile became, in effect, during its sinking, an open caisson. The 60-foot section was hoisted into an upright position by a derrick and then lowered carefully into place, where it was held by two opposing 12x12-inch timbers so bolted as to grip the pile and to guide it thereafter during the successive stages of sinking. This provision was a necessary one, inasmuch as the pile had to descend through 30 feet of water before reaching the river bed and was, therefore, exposed at times to the varying force of tidal currents.

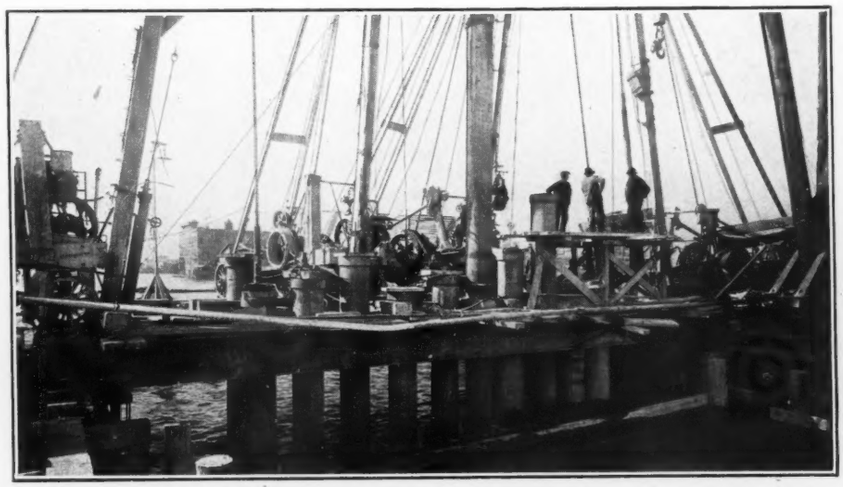
When the upper end of the original 60-foot section settled almost to the level of the working platform another 20-foot unit was coupled to it, and this procedure was followed as each succeeding 20-foot length was added until the pile reached its final resting place a foot or so in the underlying ledge. The weight of the first 60 feet of the pile was sufficient to cause it to sink unassisted about 30 feet into the mud of the river bed, but from that point on penetration had to be effected mechanically. This was done by a well-drilling machine,



Vertical section through a ventilating shaft and one of the tunnel tubes showing how the structure is supported by concrete-filled steel piles.

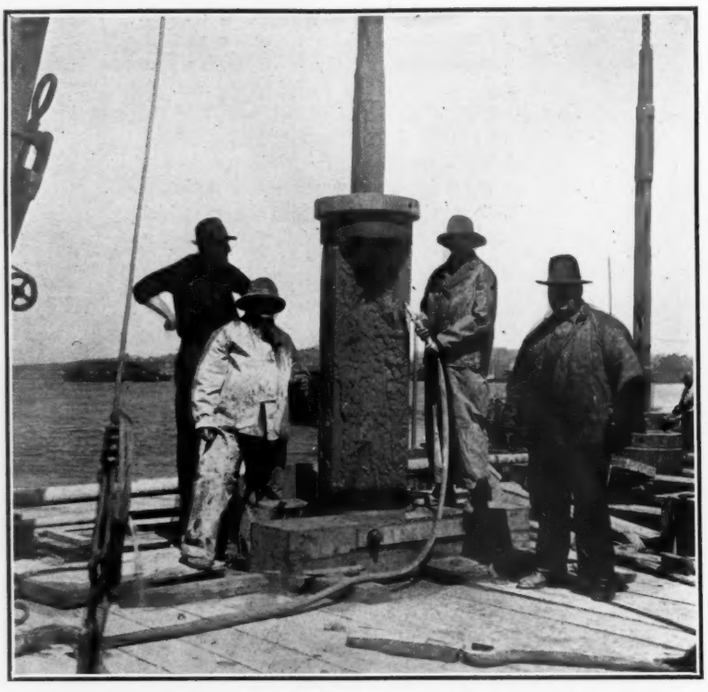
which "pumped" up and down a bit or spud ranging in weight from 2,000 to 3,000 pounds. This spud was suspended by a cable from the top of the drill derrick and was connected thence to a part of the well-drilling machine which operated on the walking-beam principle.

The spud descended through the pile and, by its vertical travel, cleared away for 20 feet below the bottom of the pile a hole in the mud into which the pile would sink by its own weight when a new unit was added at the top of the pile. According to the nature of the material of the river bed encountered thereafter, the lengthening pile would either sink freely into the excavation made by spudding and bailing or it would have to be driven into the hole by the light tapping of a hammer weighing 2,400 pounds. This was the general practice in dealing with the pile up to 180 feet in length. When the tenth, eleventh, twelfth, and thirteenth units were added, more and more force commonly had to be brought to bear by the hammer to get the pile downward and in contact with the bedrock. Spudding was continued after the rock was encountered; and a cavity ranging in depth from one to two feet was pounded out by the bit in the ledge for the lodgement of the pile foot. Before the piling was seated, however, the broken pieces of rock were cleared away and brought up to the surface by means of a specially devised bailer.



A group of four well-drilling machines engaged in sinking the first row of the piles. The position of each pile was nicely determined by a template, and the utmost care was exercised at every stage of the work to see to it that the piles were driven vertically.

It is not the purpose of this article to enter into a description of the various unique equipment developed to make the pile-sinking operations a success, but credit should be given here to the ingenuity manifested at various stages of the undertaking in meeting difficult situations and in adapting well-drilling apparatus to this rather unusual task. As can be readily grasped, it was essential that all the driven piles should stand, when in contact with the rock, as nearly true to the vertical as possible; and out of the 42 piles placed beneath the site for the north ventilating shaft, but four were more than a foot out of perpendicular alignment. Remembering that each pile was 260 feet long in its entirety and 24 inches in outside diameter, it is not surprising that the first pile sunk should have been two feet out of plumb. This was the worst of the lot; and taking the performance as a whole the results were extremely creditable.



Cleaning a well-drilling bit before lowering it into a pile for a new job. This bit or "spud" is a rectangular block of steel, weighing about 2,500 pounds, which is given an up-and-down motion by the drilling machine.

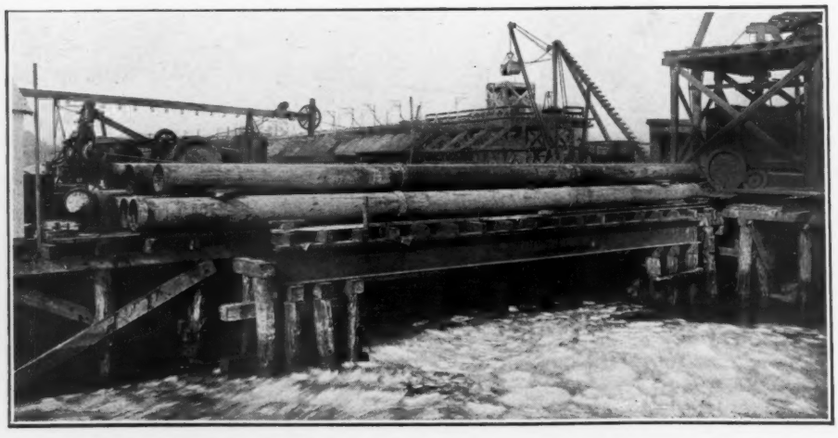
At various stages during the driving of each pile, means were employed to determine its uprightness. Apparatus were devised by which this could be done either when the interior of the pile was filled with water or when it had been drained for cleaning and inspection preparatory to inserting the reinforcing bars, etc. One of these devices consisted of a white 8-inch disc illumined by the reflected light of an incandescent bulb suspended above it. This disc was hung at the end of a cord, and could be observed during every stage of its descent within the pile. The relation of the cord laterally to the upper rim of the pile when the disc was in contact with a side of the tubing indicated whether or not and to what extent the pile was out of plumb. A plumb bob, with electric contacts, was used for the same service when a pile was full of water. The making of a contact with the interior surface of the pile served to close an electric circuit and to cause the glowing of an incandescent lamp at the surface platform. Again, the distance between the sustaining line and the lip of the upper end of the pile told how far, if any, the pile varied from the vertical.

Originally, the intention was to place the metal "basket" or reinforcing metal within the pile when driven to bedrock without unwatering the pile, but it was soon discovered that the concrete would not settle uniformly into place and produce a homogeneous body from the bottom of the pile upward to the prescribed topmost limit of the concreting. Therefore, the piles had to be washed out first by streams of water circulated by air-driven pulsometer pumps, and, with this completed, the piles were drained by reversing these pumps. Next, the reinforcing was lowered into each pile and the cement placed by a special bucket which discharged itself automatically when that container reached the bottom of the pile or the top of the cement last deposited. The lower end of each pile was bound to the rock by a seal of especially rich concrete. This plug was made up of 27 cubic feet of concrete, and it was allowed to set and harden for not less than ten days before the rest of the concrete was placed inside the pile up to the cut-off level, 106½ feet below mean high water.

With the completion of the reinforced-concrete filling, each pile was cut off just above the top of this filling by means of an internal pipe cutter lowered into the pile from above water and operated by a combination of hand and steam power. Briefly, this special tool consists of a revolving head, having a diameter of 22⅞ inches, equipped with eight radially disposed cutting dies which are fed outward as these dies work their way through the surrounding pipe wall. By means of this apparatus it has been possible to cut off all the driven piles at the prescribed depth and with a variation of a fraction of an inch. In the beginning, considerable time was required to set up the tool, do the cutting, and then withdraw the cutter, but experience made it practicable to greatly reduce this period.

Inasmuch as the upper or cut-off sections of the 24-inch cylinders penetrated more than half their length into stiff mud and silt they were firmly gripped by the surrounding river bed. Accordingly, the resistance thus offered made it at times impossible for the derricks to pull these several lengths free and to lift them to the surface. Here is where compressed air was brought into play to advantage. The top of the pile to be removed was sealed with a wrought-iron cap through which compressed air, at a pressure of 100 pounds, could be forced into the interior of the pile. When the pipe was jarred by one of the well-drilling machines it was possible to break the hold of the mud, and the propulsive action of the contained compressed air then served both to give buoyancy and to help the upward movement of the detached piping. These pile sections were generally used again—forming the lower portions of new piles driven subsequently.

Seven oil-well-drilling machines were utilized by the subcontractor in sinking or driving the 42 piles beneath the site of the caisson for the north ventilating shaft. The working force numbered about 40 men; and as many as seven piles were dealt with simultaneously. The first pile was driven on August 14, 1922, and all of them were in place, concreted, and cut off by March 1, of the present year. The work was carried on continuously day and night.



The piles were primarily assembled in lengths made up of three 20-foot sections, and as they sank or were driven through the river bed they were lengthened successively by the addition of other 20-foot units. All told each pile had a total length of about 260 feet.

Driving an 8,000-foot Tunnel to Speed Up Production of Copper

BY W. R. LINDSAY*

ALTHOUGH the presentation of the following facts is somewhat delayed, and the work has advanced considerably since the period described came to a close, still it is believed that there are features and details in connection with this undertaking which should be of current interest. Work well done in the execution of any task is always a source of encouragement and possibly a guide for the man who is about to essay a kindred job.

The No. 10 Adit of the Engels or upper mine of the Engels Copper Mining Company, Plumas County, Cal., will be approximately 8,000 feet long when completed to the point where the raise will be started to the present lowest or seventh level, 489 feet above. The Engels copper mine is now developed to the seventh level, approximately 750 feet below the surface, where the ore body outcrops. The ore and the waste from the seventh level are hoisted to the sixth level, and conveyed about 1,500 feet to the No. 6 crushing plant and terminal of the aerial tram. The aerial tram is 10,000 feet long, and its lower terminal is at the Superior mill situated 4,200 feet above sea level. The Superior mill is located near the Superior mine, so that the ore is hoisted and dumped directly into the crusher bin.

The No. 10 Adit will make it possible to do away with hoisting and pumping at the Engels mine as well as aerial tramming to the mill after the haulage system has been installed. It will also permit attaining a much larger capacity than is practicable with the present transportation system. Moreover, it will allow consolidation of the present two camps, compressor plants, shops, etc. There will be about 6,500 feet of 24-inch gage railroad between the mouth of No. 10 Adit and the top of the crusher bin, which is on a level with the adit. The Engels mine is at present delivering about 650 tons daily to the mill, and the Superior mine 400 tons.

A closer view of Adit No. 10 and its immediate surroundings.

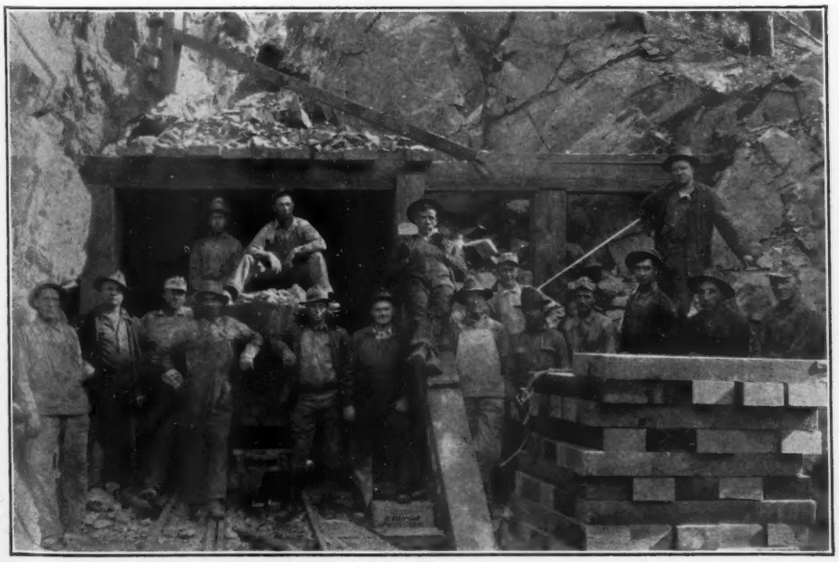
The equipment of the adit consists of an "Imperial" type 700-foot-capacity compressor, a Baldwin-Westinghouse storage-battery locomotive with charging set and switchboard, six 60-cubic foot side-dump cars, a Root type Connellsville blower, a No. 4 "Leyner" sharpener with shank and bit punch, a No. 3 oil forge, four No. 448 drills using 1¼-inch round Ingersoll-Rand Swedish steel, and one "Jackhamer" for ditching. The buildings consist of a compressor house, blacksmith shop, blower house, change house, and tool house.

The compressor was originally of a steam-driven type, but was changed over to Meese & Gottfried short-belt, motor drive. It is equipped with "Imperial" type inlet and discharge unloaders. There is no air receiver, as the compressor discharges directly into about 4,000 feet of 8¼-inch casing. The air pressure is kept at from 83 to 87 pounds. The casing is installed for the purpose of giving a permanent air supply to the Engels mine once the two compressor plants are consolidated at the Superior mine. A 2-inch pipe is used to feed water to the drilling machines.

The Baldwin-Westinghouse storage-battery locomotive is equipped with one set of 80-A 6 Edison cells, and is charged between shifts. The blower capacity is twelve cubic feet per revolution; and the motor is belted to run 215 R. P. M. It is equipped with an oil-reversing switch so that the blower can be used both for sucking and for blowing. A 14-inch, 20-gage, galvanized-iron pipe, laid on top of the air casing, is provided for ventilation. At the present face, with something like 3,500 feet of pipe, the air supply is about 1,300 cubic feet per minute.

The adit is 8x8 feet in the clear above the 24-inch gage rails, and has a ditch 2 feet wide by 1½ feet deep on the right side—the left side carrying the three pipe lines. For the most part, the passageway has been cut through hard diorite, except where it has intercepted faults or crushed areas. The rock near the portal was very siliceous, grading into light diorite with a pinkish cast. It is through this diorite that the largest section of the adit has been drilled and blasted, though gray and dark diorite, similar to the ore rock, was encountered. The tunnel was timbered at the portal, for a distance of about 139 feet, and at two sections inside where the material was crushed. These sections were from 12 to 30 feet in length. The total timbering from the portal on June 1, 1922, amounted to 189 feet of tunnel.

*Superintendent, Engels Copper Mining Company.

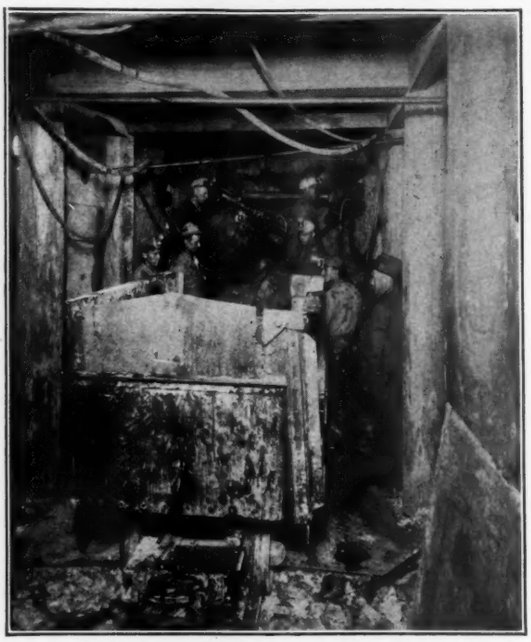


At the adit portal. Some of the men who have been responsible for the fine record which was made.

The passageway is straight except for a slight turn just inside the portal. The outside track intersects the adit line at an angle; and the curve was purposely put inside the portal, owing to the very slight intersection angle between the adit line and the hill, rather than incur the expense and the delay which would otherwise have resulted in getting under cover. The grade is .25 per cent.

The work of excavating the rock was started August, 1921, and on June 1, 1922, about 3,422 feet, including 137 feet of open cut, had been drilled and blasted. The crew at the face consists of two shifts, each made up of one shift boss; two machine men; four muckers; and one motorman. Besides, each shift includes two to six men working on the ditch and helping generally on track work and timbering.

There is also a dump man or roustabout on each shift; a tool sharpener and helper on the day shift; and a foreman superintending the whole job. The men employed on the ditch constitute a reserve force for the crew at the heading.



A timbered section of the tunnel taken close to a heading where the drills are at work.

The scale of wages for the men on the adit is the same as that paid the miners—that is, $4.50 for miners, $4.00 for muckers. In addition to this, the men at the face, the blacksmith and helper, and the foreman, are paid a bonus for monthly progress in excess of 210 feet, as follows:

210	ft.	to	220	ft.	.....	$2.00	per	ft.
220	"	"	230	"	.....	3.00	"	"
230	"	"	240	"	.....	4.00	"	"
240	"	"	250	"	.....	5.00	"	"
250	"	"	260	"	.....	6.00	"	"
260	"	"	270	"	.....	7.00	"	"
270	"	"	280	"	.....	8.00	"	"
280	"	"	290	"	.....	9.00	"	"
290	"	"	300	"	.....	10.00	"	"
300	"	"	310	"	.....	12.00	"	"
310	"	"	320	"	.....	14.00	"	"
320	"	"	330	"	.....	16.00	"	"
330	"	"	340	"	.....	18.00	"	"
340	"	"	350	"	.....	20.00	"	"
350	"	"	360	"	.....	22.00	"	"

The bonus for each ten feet, no matter what progress is made, applies only to that ten feet. The total is divided, according to shifts worked, among all the men entitled to a bonus; but no man receives a bonus who has not worked the last ten shifts of the month—the only allowance made being for sickness or absence with the consent of the foreman.

The two shifts work eight hours each, except in case of trouble when they work overtime to get the round out. Ordinarily, no overtime is paid for this work—the company figures that this is taken care of by the bonus. In such a case, the crew works ten to twelve hours to finish the round, but this does not happen often.

The round is drilled with a pyramid cut and with from 16 to 24 holes, averaging about 6½ feet deep. In order that the operations may not be interrupted, two of the drilling machines are kept in reserve—the other two being used at the face. In this connection it is interesting to note that the cost of drill repair parts per foot of advance, covering a period of fourteen months, amounted to but $.0946. Forty per cent. gelatin dynamite is commonly employed; but occasionally a few sticks of 60 per cent. are put in the bottom of cut holes. The ventilating blower is active between shifts to suck out the noxious gases, and when the shift is on it is reversed and used to blow fresh air into the passageway. The compressor is also made to blow for about ten minutes after blasting, as this stirs up the smoke at the face and forces it back to the ventilating pipe, which is kept 80 to 100 feet away from the face.

The following table gives figures of cost and of progress for each month up to September, 1922. Equipment cost covers moving and installing of compressor, but not first cost; new shank and bit punch; six new cars; new locomotive; drills and first set of drill steel; installation of blower not including first cost; all buildings and grading for same; pipe lines; and track to tunnel portal. The machinery which shows no first cost was already at the mine when the adit was started.

Month		Progress in feet		Equipment cost	Driving cost	Driving cost per foot
July,	1921			$4,920.04		
Aug.,	"	176.20		4,589.10	$3,210.79	$18.22
Sept.,	"	291.28	(timbr.)	1,500.41	6,796.15	23.33
Oct.,	"	372.38		867.47	7,876.37	21.15
Nov.,	"	345.60	(timbr.)	5,830.07	8,116.36	23.48
Dec.,	"	375.91		754.00	8,531.65	22.70
Jan.,	1922	383.40		774.24	8,809.22	22.98
Feb.,	"	371.82		261.79	8,143.25	21.90
Mar.,	"	383.18			9,865.25	25.75
Apr.,	"	397.22			9,662.69	24.33
May,	"	325.29	(timbr.)		7,686.62	23.63
June,	"	345.23			7,923.71	23.10
July,	"	350.73			8,449.41	24.09
Aug.,	"	388.90			9,667.60	24.86
Sept.,	"	347.05		113.28	7,957.76	22.93
Total	.....	4854.19		$19,610.40	$112,696.83	$23.27*

*Averaging driving cost per foot.

The data next given are supplemental and embrace the results of operations during an earlier period when all work was underground—that is from September 1, 1921, to June 1, 1922.

Man shifts	6,621
Machine shifts	1,032
Cars of muck	7,832
	Advance in feet
Per man shift	.4904
Per machine shift	3.1450
Per round	6.3030
Per month, average	360.7000
Total	3,246.0000
	Tonnage broken
Per man shift	3.843
Per machine shift	24.670
Per round	49.420
Per hole	2.700
Per foot of drilling	.391
Per foot of advance	7.840
Cars per foot	2.413
Total muck	25,455.000
	Holes
Per round	18.3
Per foot of advance	2.9
Per machine shift	9.2
Total drilled	9,435.0
Average depth of hole, in feet	6.9
	Feet drilled
Per foot of advance	20.06
Per machine shift	63.10
Per round	126.40
Per ton broken	2.56
Total	65,118.00

Progress on this job could, no doubt, have been increased considerably by putting on another shift, but this would also have increased the cost per foot of advance. As the work is being carried on now, the adit is always clear when the relief shift comes on; and, furthermore, if the round is not blasted in eight hours the crew stays on the job until it is finished. Thus the face is left ready for the succeeding shift to begin the regular routine of mucking, drilling, and blasting.

The goatskin tanners in the United States occupy a rather unique position in the tanning industry of the world. Although the production of goatskins in the United States is almost negligible, we supply 75 per cent. of the world's output of glazed kid. About 85 per cent. of our production of glazed kid is manufactured in tanneries located around Philadelphia, Pa.

Due to the offer of a bounty of £5 for every ton of copper mined in the Union of South Africa, reduction operations have been resumed in the Transvaal. The copper is to be used in connection with the electrification of certain Natal railway lines.

Next to agriculture, the railways of the United States represent the country's largest industry. It is estimated that on a given day the average value of freight in transit on the far-flung lines is $2,500,000,000.

Compressed Air Safeguards Aquatic Life

Careful Measures Taken in the World's Greatest Aquarium to Keep the Water Fit

BY ROBERT G. SKERRETT

"HE DRINKS like a fish," may answer fairly well as a description of a dissolute human being but the phrase certainly misrepresents the fish. Most of us imagine that fish need only water and much of it in order to thrive; and it will probably surprise many thousands of us to be told that these aquatic creatures would soon perish if they were denied a plenty of air.

A near view of fish in a glazed tank seems to reveal that they can "stay down" indefinitely, and, so far as the eye betrays, these animals deliberately remain below the surface and generally avoid contact with man's essential atmosphere. Just the same, despite appearances, an ample supply of air is vitally necessary to the finny denizens of lake, stream, river, and the sea's depths. Comparatively few of us have appreciated this fundamental fact.

Contrary to the common understanding, fish must have oxygen in a gaseous form to maintain their vital processes; and the watery element in which they thrive has this life-giving medium distributed throughout its mass even though the presence of the air may be invisible to the unaided eye. But this does not mean that water always has within it sufficient air to meet the requirements of the fish therein; and seasonal conditions may actually so far deplete the measure of oxygen in the water as to bring about the suffocation of the aquatic creatures. If, for any reason, physical circumstances hamper or obstruct the movement of air from the atmosphere into the mass of a body of water, then that water may, in a comparatively short while, become so deficient in its oxygen content as to be incapable of sustaining animal life.

A year or two ago, large numbers of fish were found floating dead upon the surface of a western lake. While an analysis of the water disclosed no impurities that might have accounted for the sacrifice, still the chemists discovered a notably reduced percentage of oxygen in the water. The explanation for this unusual condition was a simple one: for some weeks the weather had been very warm and the winds decidedly light and infrequent. The heat and the stillness of the air were together responsible for the state of the water which was not fit to meet the vital needs of the fish that had succumbed. Again, a period of severe cold, which kept a lake completely covered with ice for an exceptional length of time, was equally destructive to fish life inasmuch as the icy barrier isolated the water from the atmosphere and effectually halted the normal transference of oxygen.

It has been established by the physicist and the biologist that the amount of a given gas which pure water will dissolve depends upon temperature, pressure, and the relative solubility of the gas. It is a matter of common knowledge that a bottle of soda water is charged, that is, the water is made to take up in solution a quantity of carbonic acid gas, by subjecting both the gas and the water to pressure. This is nothing more than a deliberate exaggeration of what Nature does, herself. Under increased pressure, the capacity of water for holding any gas is correspondingly augmented, while, on the other hand, rising temperature causes the water to give off some of the gases held in solution, and the measure of this exhalation, so to speak, is dependent upon the temperature and its duration. Similarly, warm water is less capable of absorbing atmospheric gases.

Although oxygen and nitrogen, which constitute 90-odd per cent. of the atmosphere, are but slightly soluble in water, carbonic-acid gas, on the other hand, which is present in the air, is extremely soluble in water, and CO_2, unfortunately, is harmful rather than helpful in promoting animal life. Tumbling mountain streams, storm-tossed or wind-swept waters, the pounding surf, and the broad surfaces of any considerable aqueous body serve to keep up the aeration required to sustain animate creatures within the water. Further, aquatic vegetation,

Just once so often the water in each of the tanks must be freshened by means of aeration. This is done by forcing compressed air through a pipe terminating in a cap, which atomizes the air so that the water will readily absorb the minute bubbles.

The aerator in action discharging a stream of minute bubbles into one of the Aquarium tanks. In this way the needful oxygen is distributed throughout the water.

especially the submerged sorts, are peculiarly fitted to transform into gaseous oxygen the oxygen held in solution by the enveloping water and thus to put this life-giving gas at the disposal of fish.

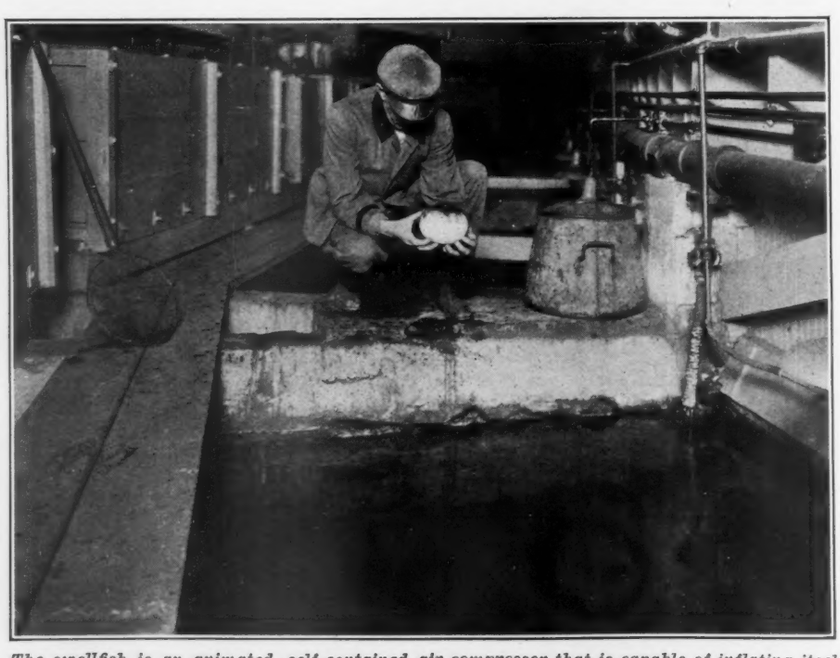
But when man sees fit to take fish from their native habitat and to place them in tanks or pools where Nature's revitalizing cycle may be interrupted or impeded, then something else must be done that will fulfill the same function and restore to the water that measure of gaseous oxygen normally present when a proper state of saturation or equilibrium prevails. The rapidity with which water becomes supersaturated with atmospheric gases or deficient in its gaseous content is largely controlled—other things being equal—by the area of its superficial contact with the free air. It should, therefore, be self-evident that water only moderately exposed to the atmosphere, as in aquarium tanks, artificial pools, etc., may reach an abnormal or subnormal gaseous condition and remain so for some while unless means are taken to correct it.

And, now, a few words about what happens when a fish seems to be drinking water more or less continuously. Fish breathe through their gills, which consist of four double rows of cartilaginous leaflets, so the physiologist tells us; and it is the network of blood vessels distributed throughout these membranes which gives the gills their bright red color in health. Although the blood in those tiny vessels does not come directly in contact with the gaseous oxygen in the water, still the oxygen, by a well-known physical action, makes its way through the intervening layer and enters the circulatory system. In the same way, other gases held in the water may pass into the fish's blood; and, oppositely, outward bound or exhaled gases return to the water from the lungs of the fish by this route. Therefore, when a fish appears to be drinking it may, on the contrary, be breathing. Fish may succumb to "gas disease" unless the gaseous content of the water is kept reasonably uniform—some fish being more sensitive to variations than others. A large number of fish in a confined body of water, like too many people in a closed room, may induce the rapid depletion of the oxygen supply, and this may have fatal results.

As an example of what should be done to prevent losses and to keep fish healthy while in confinement, we shall now describe what is the practice at the New York Aquarium. This public institution, which is the largest aquarium in the world, is annually visited by more than 2,000,000 people because of the scope of its exhibits and the extremely attractive manner in which the many species of aquatic creatures are displayed. The Aquarium is about to have its facilities amplified, but at the present time it has 7 big floor pools, 94 large wall tanks, and no fewer than 30 smaller tanks. Sea water and fresh water are provided, according to the needs of the different kinds of fish, and arrangements exist for heating and for chilling the water to suit tropical creatures or fish that are accustomed to the colder waters of northern latitudes.

The still water of an aquarium or of a tank filled with fish for transportation would soon become "stale" if it were not aerated artificially. This can be accomplished by dipping out some of the water at frequent intervals and dropping it back again through the air, or air can be sprayed into the mass of the water to achieve the same end. It is for this latter service that a compressor forms part of the mechanical equipment of the New York Aquarium. The circulatory system of the Aquarium is such that running water is generally available, and dropping as it does a short distance from the feed-pipe outlets into the tanks it catches air on the way and carries that air down into the water in the tanks. But what happens when, for one reason or another, the movement of this water supply is halted? It is impracticable to bail the water and aerate all the tanks in that manner. Then it is that the compressor is brought into play as a matter of course; and experience has revealed that it is likewise needful to aerate the water occasionally even when the flow is not interrupted.

The arrangement for the foregoing service is fairly simple. The electrically driven compressor maintains in a receiver a supply of air at approximately 40 pounds pressure, and this tank is joined with a piping system which runs to all the wall tanks. At each tank there is connected a length of rubber hose to which is attached a short metal tube which terminates in a vulcanite cap pierced by three passages—each of which is filled with a plug of porous basswood. When compressed air is turned into the line and run through one of these "liberators," the air issues from these plugs in a finely atomized stream. With the liberator submerged, a flow of tiny bubbles gushes from each plug, and these bubbles are distributed throughout the mass of the water, commingle with it, and a certain percentage of



The swellfish is an animated, self-contained air compressor that is capable of inflating itself in the manner shown whenever it wishes to float upon the surface of the water.

the gaseous oxygen is caught and retained by it. The greater the number and the bigger the fish in a given volume of water the more it is necessary to neutralize the effects of the carbonic acid gas thrown off by the fish and held in solution by the water, and, therefore, the larger the measure of air which must be forced into the water to accomplish this end.

A while back, foul gases collected in the water in sufficient quantity during a single night to kill about 140 of the fish. The victims were among the fish that usually swim high or near the surface. Apparently, the depletion of life-giving oxygen was most in evidence in the upper strata of the liquid. The practice now at the Aquarium is to aerate every wall tank once a week by means of compressed air and for a period of six hours. This precaution has effectually prevented a noxious accumulation of gases, and such deaths as have since occurred among the finny denizens have been due to other causes.

For fresh-water fish the water is tapped from the municipal mains, but for the exhibits of sea life only water from the Atlantic will answer. In the course of a year the Aquarium uses 100,000 gallons of ocean brine; and owing to the precautions taken and the facilities provided this quantity of water does service over and over again—in fact, it circulates at such a rate that there is an actual flow of 300,000 gallons daily, according to Dr. Charles H. Townsend, the Director of the Aquarium. When the salt water is brought in from the offshore depths it is stored in a large reservoir; and because of the "closed-circuit system" of distribution, the water that is pumped to the exhibition tanks has actually been in constant service for years. This would not be practicable but for the use of filters, of which there are two.

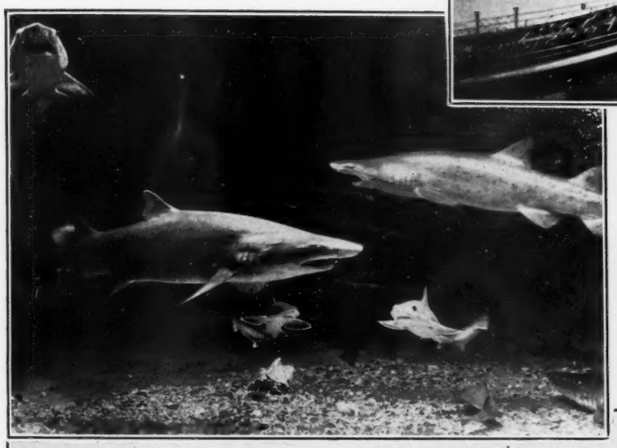
Each filter has an 18-inch bed of quartz sand, and when the water has percolated through this cleansing agent the water is sent thence to the receiving reservoir to be pumped again into the exhibition tanks. One filter is idle while the other is in service; and the sand in the idle filter is cleaned before it is utilized again. In fact, the sand in each filter is purged every week by reversing the flow of water through the bed and by stimulating the cleansing through the medium of an underlying aerating coil. This coil is fashioned of lead pipe having numerous little openings made by sawing shallow notches across the upper surface. Compressed air is forced through and out of this coil for an interval of two hours. The air bubbles rising through the overlying sand augment the washing action of the water.

The compressor figures helpfully in another direction in maintaining the water in the Aquarium in a condition to meet the needs of certain of the aquatic creatures. The fish from northern waters, as has previously been mentioned, require a lower temperature than is normal to the water in the Aquarium during the summer time. That is to say, these northern fishes do not flourish, in fact might die, if the temperature of the water rises above 54°F. Therefore, beginning with June, the water for these particular creatures is kept at a proper temperature by a refrigerating plant which is equipped with an ammonia compressor having a refrigerating capacity of 13.6 tons per diem.

Inasmuch as the Aquarium draws upon far and wide for its attractive features, it will probably be of interest to many to learn how the fish are transported from their native waters and delivered in a vigorous condition in New York. Success in this is largely due to the Aquarium's ocean-going tender, the *Sea Horse,* which, once so often, voyages southward to the West Indies in quest of the rare

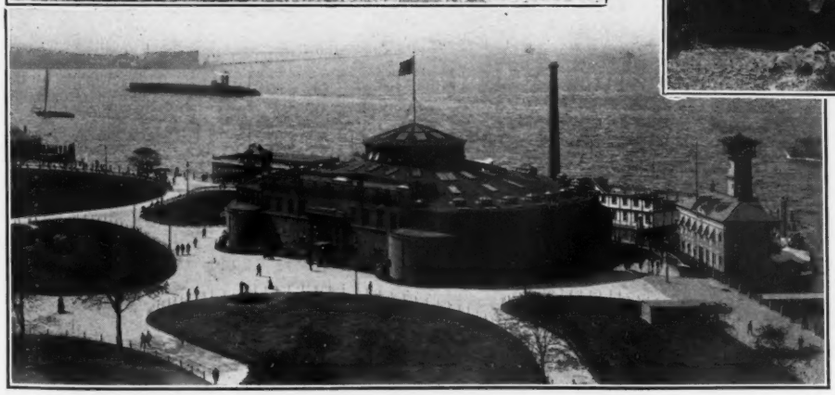
The main chamber of the Aquarium where there are seven big floor pools, 94 large wall tanks, and 30 smaller tanks for the accommodation of a great variety of aquatic creatures.

Sand sharks and shark suckers. The latter, which are the small fish, attach themselves to the bellies of the sharks and are towed around by their hosts.



Courtesy N. Y. Zoological Society.

A group of spadefish. These vividly marked fish are among the most spectacular in the Aquarium.



The New York Aquarium which has developed from a fort built in 1807. The present institution is the largest of its kind in the world, and is visited annually by more than 2,000,000 sightseers.

Behind the scenes at New York City's great Aquarium. Each tank is equipped with an aerator, indicated by the white arrow, which can be dropped into the water and set going whenever necessary.

and beautiful finny denizens of the tropics. Let us suppose that the *Sea Horse* has been successful and that she has turned her nose toward higher latitudes.

As long as the sturdy little craft threads her way northward in the sweep of the warm and salt-laden Gulf Stream, water for the live tanks and the well is pumped freely in from the Atlantic. But when the tender parts company with that beneficent oceanic river, then the surrounding water cannot be used lest its chill endanger the captive fish. Thereafter, until the Port of New York is reached, the water in the tanks must be maintained at the temperature prescribed by Nature; and, further, to keep the water fresh and fit, it must be aerated just once so often on the run from the Gulf Stream to the Aquarium. For this purpose the *Sea Horse* is equipped with a small air compressor; and liberators, such as have already been described, are used to distribute the air within the tanks.

PNEUMATIC CYLINDERS TO PREVENT AIRPLANE DAMAGE

TO OBVIATE breakage of the underbodies of airplanes when coming to earth, a Britisher has invented a so-called "uncrushable" chassis. The new underbody looks just like any other two-wheeled chassis, but is provided with a system of pneumatic cylinders designed to prevent damage even when the machine is carelessly landed by an inexperienced pilot.

Recent tests of the pneumatic underbody proved that it could withstand shocks that would smash the ordinary chassis. The aviator, who demonstrated the practicability of the device, flew the machine at full speed against the ground at an angle that would have broken the average 'plane or turned it over on its nose. As it was, so reports have it, the pneumatic underbody absorbed the shock without even bouncing.

MAKING CRYSTALS FOR THE CRYSTAL GAZER

FOR CENTURIES, in the Far East, the mystic crystal gazer has been able, so it would seem, to peer steadily into the depths of a limpid sphere and thus induce a state of self-hypnotism by which the future might be revealed in a series of fleeting visions. The crystals employed for this purpose have generally been fashioned from carefully chosen pieces of fine crystal quartz. Skill of an exceptional character has been essential always in producing these perfectly formed and highly polished transparent balls.

First, the craftsman has patiently chipped his raw material roughly into the semblance of a sphere, and then by means and cunning, which he has kept as secret as possible, he has gradually reduced the surface inequalities by grinding—spending a great deal of time to obtain the desired state. Next, but less laboriously, he has used suitable abrasives and polishing materials, obtaining in the end a glistening globe of marvelous perfection and water-like clearness. So much for the Asiatic artisan and his exquisite handiwork.

Here, in America, we are much more practical in meeting the demands of the frivolous-minded or the would-be crystal gazers who ply their trade like the common palm readers at country fairs, seaside resorts, and other places of recreation and amusement. A great many of the crystals used by these fakers are not really spheres formed from quartz but are nothing more pretentious than cleverly modeled balls of glass.

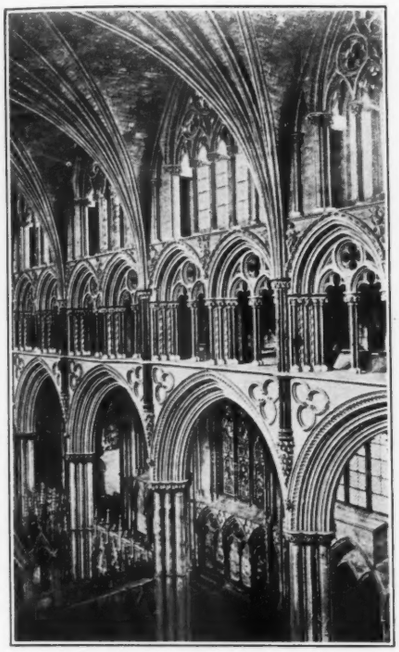
Down in the Monongahela Valley of West Virginia, at one of the plants engaged in the manufacture of fine, pressed glassware, there is an operative who devotes many a noon hour to turning out glass spheres for the crystal gazers of the Western World. He makes a tidy sum in this way. From a pot in the furnace, he gathers sufficient molten glass on the end of an iron rod or pipe to serve his purpose; and while this glass is glowing and plastic he kneads it into a globular form by means of a wet, cup-like mold of wood which he manipulates skilfully so as to shape the hardening glass into a sphere. With this done, it is necessary only for him to separate the globe from the remaining neck of glass by a sharp blow, after which the surplus glass at that point is ground away. The action of the wooden former, besides shaping the glass, tends to impart a finishing polish.

How balls of glass are now made for the crystal gazer. Being red hot the glass has photographed like a sphere of jet.

Compressed Air and Concrete Save Old English Cathedrals

The Pneumatic Placing of Grout is Offsetting the Ravages of Time and Revitalizing the Walls of Ancient British Structures

By FRANCIS J. TIETSORT



Triforium in Angel Choir, Lincoln Cathedral.

The beautiful west front of Lincoln Cathedral.

The Morning Chapel of Lincoln Cathedral.

THERE are few religious edifices of any description in young America that have been standing in their original state for a century, but the lands of America's forbears, Britain and the continental countries, possess among their chief architectural glories towering and hoary piles of magnificence centuries old—Cathedral monuments of Christian faith.

One of the chief delights of American visitors abroad is to view from within and without these impressive tributes of civilized art to the influence of the church. In the heart of the ancient city of Vienna there stands a cathedral more than 1,000 years old, the stone floor slabs of which are worn with the feet of countless worshippers. Through all its existence, a continuing commission has, in a time span of more than two-score generations, kept the structure in repair.

Cathedrals, through the storms of winter and the sun and the rain of summer, must be watched and tended with expert eyes and hands, for atmospheric conditions ravage even stone and cement. The earliest and most glorious of Gothic cathedrals at Cologne, whose wonderful arches seem like lacework in varicolored shadows thrown by its beautiful stained-glass windows, has required constant care for eight centuries. The cathedrals of England, of which there are some splendid examples, have a peculiar and sentimental interest for many thousands of Americans, and for obvious reasons. At the same time they are treasured in Britain as among the rarest and the most significant possessions of the nation.

The Very Reverend, the Dean of Lincoln, has recently completed a three months' visit to the United States, during which he narrated a tale of modern engineering as applied to Lincoln Cathedral. It naturally finds a place in these columns because means have been found to perform a splendid work through the agency of compressed air.

To an engineer or practical mechanic, it is becoming almost trite to refer to the wonders worked by compressed air in the realms of mining, industry, and manufacture, but T. C. Fry, the venerable Dean of Lincoln, gives us an unusual and an entirely new account of a highly practical use for compressed air—the saving from ruin of England's ancient cathedrals.

Lincoln Cathedral, one of the oldest and finest in England, was originally built by the Normans almost nine centuries ago—Gothic wings and towers having been added when it was subsequently enlarged by early English builders. The magnificent towers of Lincoln Cathedral loom to the height of some American skyscrapers. As an architectural whole, the great structure is a thing of beauty. The Dean explained, however, that if certain discoveries had not been made in December of 1921, sections of the vast and classic edifice might soon have come tumbling to earth.

Such a thing actually happened once in the case of Ely Cathedral, when the great central tower, built by the first Norman abbot (1082-1094), fell down in 1321, 227 years after its completion. It carried with it portions of the adjoining bays of the nave, transept, and choir, and great was the damage thereby. It bid fair to happen at Winchester Cathedral a few years ago, until ingenious engineers brought compressed air into play; and it was from the successful experiment at Winchester that the authorities at Lincoln got their salvaging idea.

Engineers at Lincoln found very dangerous cracks, some nearly a foot wide, in the walls and foundations supporting thousands of tons of solid masonry. It was also discovered that the fissures were slowly widening on account of the continuous pressure. The work of repair began early in 1922, when the examining engineers and architects established that most of the original structure was very unsafe, owing to the fact that the Norman workmen had filled in the interstices of the walls with rubble, much of which had gone to dust in the course of nearly 1,000 years. It was deemed expedient, by the aid of suitable equipment, to pour into the walls of the northwest tower, from the base upward, tons of concrete so as to render it secure.

But this was not all. Parts of the southwest tower were found to be in a precarious state and called for quick action. There was also a crack across the west front of the structure, which has to be rebound to the body of the building. Similar work is required to secure the north wall of the nave; and the central tower, although not in such bad shape as the northwest tower, should have prompt attention.

It is estimated that it will cost $250,000 to make the entire cathedral safe, and that it will

take five years to complete the work. The Dean said that he raised $100,000 at once in England; that many American churchmen of the Episcopal faith, who have visited the cathedral and have a sentimental interest in it, were providing $50,000; and that the remaining $100,000 would be subscribed in England.

While in this country, the Dean received many voluntary gifts from American church communicants; and the intention is to place a bronze memorial tablet at the base of the central tower of the cathedral which will tell that the restoration of that section was due to the generosity of American friends. It might be recalled here that many American contributions were made two or more years ago towards the repairs on Westminster Abbey in London, as was also done in the case of the restoration of Rheims Cathedral. There is a common recognition that such structures are in reality not the property of any one nation, but of all the world.

A part of the ancient Roman wall and water tower at Chester, England, indicating the character of the stonework reared in those ancient days.

The feature, however, which interests us most in connection with the restoration of Lincoln Cathedral is the use of compressed air. One of two committees, formed by Lord Yarborough to supervise and to finance the work, concerned itself with the engineering task involved. This committee is composed of prominent engineers and leading laymen of the County and City of Lincoln, who have volunteered their services without pay. Their advisers are: Sir Charles Nicholson, Bart., the architect, and Sir Francis Fox, an eminent English engineer, who was largely responsible for saving Winchester Cathedral from collapse. Both of these experts are giving their services to the preservation of this famous edifice. Sir Francis at once brought into play facilities like those previously used by him to restore the ancient Roman walls about the City of Chester, on the border of Wales, and the walls of Winchester Cathedral.

The mechanical equipment consists of an electric motor, an air compressor, pneumatic drills, a compressed air receiver, and a cement mixer and tank. A fluid concrete or grouting, of a high binding character, is forced by air pressure into the cracks and crevices until they are completely filled. But not until the work of grouting was actually begun was the crumbling nature of the inside of the walls revealed. While one hole may need but half a gallon or so of concrete to completely fill it, another opening will prove insatiable for the simple reason that the grouting has been known to filter through the interior of the wall for a distance of 60 feet as it crowded into the interstices left by the disintegrated rubble. A ton and more of concrete has thus been poured into a cavity about ten feet square which still remained unfilled.

But before grouting is commenced, holes are bored into the walls of the cathedral anywhere from ten to twenty feet deep. The air for the pneumatic tools employed for this part of the job is fed from the compressor through piping run up the sides of the cathedral. The drills do their work efficiently and rapidly—penetrating the "ashlar," or hewn stone, from four to five feet a minute. It is obvious that compressed air is certainly saving the day, inasmuch as hand drilling—operating as the men must at times high aloft on scaffolding—could never have been resorted to for this important phase of the task of restoration. Into each hole is then placed a reinforcing rod of delta bronze—a rustproof metal capable of withstanding great strain. It is claimed by the experts that Lincoln Cathedral, upon completion of the work, will be stronger than it was when originally built.

One of the menacing cracks in the foundation walls of Lincoln Cathedral. These fractures have gravely endangered the entire structure.

It is needless to add that the work now being done by Sir Francis is attracting the attention of engineers throughout the world, because of its interesting and unusual nature. Here, it would seem, is a new angle in the field of compressed air, with unlimited and significant possibilities, in the maintenance and repair of masonry bridges, towers, and other stone structures.

The eyes of the worthy Dean twinkled as he narrated the facts of the saving of his beloved cathedral. He commented: "I have understood that America is the home of compressed air, that its extensive commercial use was brought about largely by an American corporation which has pushed its development for the last half century. So I am happy that I can bring to the attention of interested people in the United States a novel use of this power medium in saving ancient edifices.

"I felt sure that your engineers would wish to learn what we are doing with compressed air in Old Albion. Sir Francis tells me that new uses for compressed air are being discovered almost daily; but I would be tempted to lay a wager that you Americans never before heard of its application in the salvation of ecclesiastical architecture."

ARTIFICIAL SILK

ONE of the most rapid and astonishing of industrial developments is in the production of artificial silk, with the United States far in the lead. Mr. S. A. Salvage, Vice President of the Viscose Company, stated in a recent address that, with a start of little more than a decade, the world's production of artificial silk exceeds that of natural silk by at least one-third.

The annual output of the three leading producers is: United States, 23,500,000 pounds; England, 15,340,000; Germany, 12,584,000. With the completion of the new plant of the Viscose Company in the Philadelphia district it is stated that the annual production capacity will reach 40,000,000 pounds a year.

According to the *Kansas City Times*, workmen engaged in a cold-storage plant at Zelah, Wash., uncovered three boxes of apples which, upon investigation, were found to have been in storage for five years. The fruit was in excellent condition.

Java Developing Her Water-Power Resources

The Electrification of Her Railways Already Well Under Way

BY RICHARD HOADLEY TINGLEY

THE COAL resources of the Dutch East Indies are limited and largely undeveloped. That the home supply is insufficient to meet the demand is evidenced by the fact that this colony annually imports from 200,000 to 500,000 tons, and exports none. The principal mines, owned and operated by the government, are the Ombilin, near Padang on the west coast of the Island of Sumatra; the Boekit Asem collieries near Palembang, toward the east coast of the same island; and those on the small Island of Pulo Laut off the southeast coast of Borneo. The total annual production of these mines is barely 500,000 tons—a large portion of which finds its way to the sister Island of Java, the largest user of coal, where practically none is mined.

Recognizing the folly of continuing to import coal while permitting its many water-power resources to remain in an undeveloped state, the government, in 1910, organized a new branch of service and appointed Mr. P. A. Roelofsen, C. E., now Director of Public Works, Director of the Department of Water Power and Electricity, with instructions to report upon the hydro-electric potentialities of the Dutch East Indian possessions as well as upon the water-power sites already developed.

Mr. Roelofsen's report, which does not include certain of the innumerable lesser islands or much of the little-known part of Dutch New Guinea, summarizes the hydro-electric possibilities as follows:

Java	500,000 H. P.
Sumatra	2,000,000 H. P.
North Borneo	2,000,000 H. P.
Celebes	1,000,000 H. P.
Total	5,500,000 H. P.

We shall say but little about any of the islands except Java. The others referred to are largely undeveloped, and it will be many years before any of them will be so advanced that it will be practicable to utilize even a small portion of the water-power resources accredited to them. With Java, however, the case is different. This island has a population of about 33,000,000—710 to the square mile, and is by far the most densely inhabited country in the world. Its nearest approach is Belgium, with 650 people per square mile. Of this population, about 110,000 are whites, who are an important factor in the commercial life of the island, while the rest are native Javanese with a sprinkling of Chinese and other Asiatics.

INSULINDE is the musical name now given the Dutch East Indies, among which are five islands of nearly continental magnitude. Java is one of these.

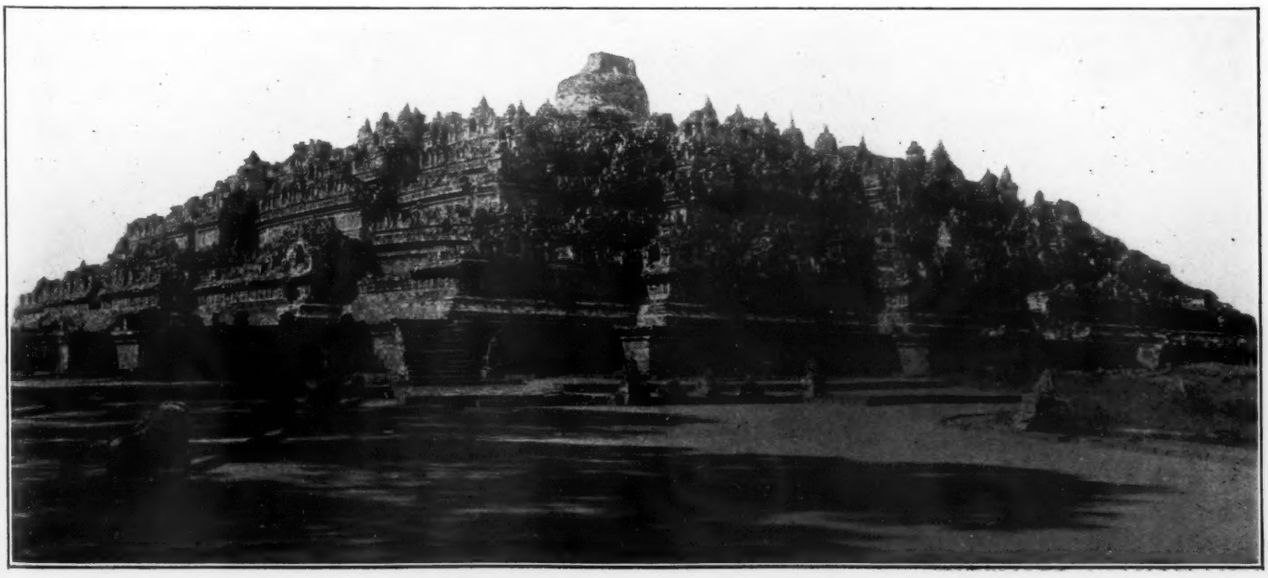
In the centuries that have followed since Magellan set out in 1519 in quest of a westward passage to the Spice Islands, whose commodities were then worth their weight in gold, Java has shaken off her erstwhile oriental sloth and has grown prosperous and populous under her progressive Colonial Government.

Java is keeping abreast of engineering developments; and, to this end, her waterfalls are being harnessed so that they can generate electric current for lighting and industry but mainly for the electrification of the island's ramifying railways.

Java is the garden spot of the Dutch East Indies and the most highly developed of the islands. In size it is about equal to that of the State of New York. From the shore line to the base of the mountains that form the backbone of the island, intensive cultivation is in progress the year round and there all the agricultural products are raised for domestic use and for export. So important and valuable are these that Java has been able, in consequence, to maintain for many years a favorable trade balance with the outside world.

Railway construction began in Java in 1878 with a short section of 36 miles from Surabaya to Passoeroean. Since that time a system of about 3,000 miles has been built—1,550 miles of which is owned and operated by the government and the remainder by twelve private companies. The greater portion of this mileage is of their standard gage, that is, three feet six inches. A small part, however, is distinctly narrow gage, about two feet, and another small portion is equal to the United States standard of 4 feet 8½ inches. Some idea of the comparative extensiveness of Java's railway development may be had when it is realized that this island maintains a mile of track for each seventeen square miles of its area as against a mile for each twelve square miles in the United States.

Java is about 600 miles long and has an average width of something less than 100 miles. For fully half of its western length it is traversed by two railway lines, which are approximately 60 to 80 miles apart, while its



Hindu temple in the heart of Java near Djokjakarta.

eastern end is served by a single main line. Throughout the island there are many branches, running north and south, which connect important sections. The roadbed is excellent, the service is good, and the companies are prosperous. At present it takes a day and a half to travel from Batavia, on the west, to Surabaya, on the east. For economic reasons, unknown to the writer, Java trains do not run at night; and a through passenger is, therefore, obliged to spend the night at some city en route.

The Department of Public Works estimates that if the available water power were developed to capacity—50,000 H. P., it would be sufficient to operate the entire railway system and to leave, besides, a surplus for industrial and public-utility uses. A carefully worked out plan has been prepared looking to that end which, it is hoped, will be fully realized in about ten years, or sooner, should financial conditions warrant. In this manner the Dutch East Indian government hopes to be able to stop the imporation of coal—thus saving that product for other uses and for export.

In the nature of things, however, Java's water-power resources are small. The drainage basins are restricted in area because the streams all flow in a generally north or south direction—the short way of the island. This deficiency is partly overcome by a very heavy rainfall—which ranges from an average of 120 to 160 inches annually and reaches, occasionally, as high as 320 inches in the more mountainous regions—and by the high head of many of the streams as they tumble down the steep slopes.

Java's dry season occurs in May, June, and July, while its period of greatest precipitation is in November, December, and January. The normal average flow of the streams is rated at 175 second-feet —reaching 700 second-feet at times. It is estimated that the largest single source of water power is capable of developing about 50,000 H. P. The majority of the prospects, however, are rated at from 1,000 to 5,000 H. P. Most of the developed and undeveloped hydro-electric resources are in western and central western Java.

The principal activity in Java's water-power development is centered, at the present time, in the westernmost end of the island where two power stations are being constructed—a portion of the current there generated to be utilized in operating the existing railway line running from the harbor of Tandjong Priok, through Batavia, Weltevreden, Buitenzorg, thence southerly and easterly toward Bandong, a total distance of about 60 miles. The larger of the hydro-electric stations is at Tji Anten (*tji* meaning river), some twelve miles west of Buitenzorg, and has a capacity of 25,000 H. P. The smaller one at Tji Tjatih, about 30 miles south of Buitenzorg, has a capacity of 15,000 H. P. It is expected that these stations will be in full operation, and the railway lines electrified, sometime in 1923, thus forming the first link in the chain of electrification which will extend eastward, 500 miles, to Surabaya. The work is in charge of Dr. J. N. Van Der Ley, who succeeded Mr. Roelofsen in this branch of the service.

The primary power developed at each station is of 70,000 volts, 3-phase, 50 cycles. For railway use the current is transformed to 1,500 volts for distribution and further transformation. Much of the equipment for the power houses and transmission lines is being purchased in the United States. This includes 60 galvanized-steel towers, each 75 feet high, equipped with three cross-arms for a double 3-phase line. Upwards of 900,000 pounds of hard-drawn copper cable has also been bought in this country. This cable is of two sizes, that is, 50 and 70 square millimeters, and each is composed of seven wires. Furthermore, we furnished much of the smaller power-house and transmission-line material. There was lively competition between Europe and the United States to get the contracts for much of the larger equipment, and in this bidding the homeland, Holland, obtained a preferential, sometimes as high as 15 per cent., over other countries, notwithstanding the long-established free-trade policy of The Netherlands and her colonies.

A beautiful and suggestive example of Java's water-power resources.

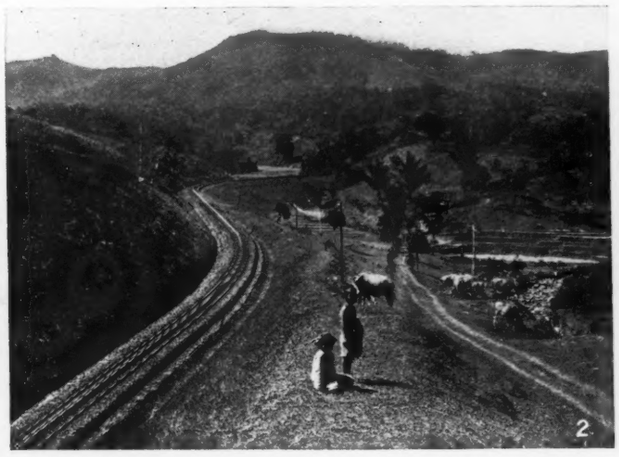
In addition, there are under construction state hydro-electric stations on Tji Kapoendoeng, near Bandong, to be of 3,000 H. P. capacity, and on the Tji Saroewa, near Pangalengen, of 4,500 H. P. Farther east two small stations are being built—one, an auxiliary plant of 400 H. P. on the Tji Hapit, at Bandong, and another of about 1,000 H. P. for radio purposes south of Bandong. All the stations already built or under construction have been planned to fit into the general developmental scheme of the island, and are to be so interlinked that they will be able to assist one another in times of need.

Perhaps the most important of the hydro-electric plants alreadys operating in Java is that in the Tjatoer valley, near Madiun. At Madiun are located the extensive shops of the government railway; and the increased traffic in 1911 and 1912 made the enlargement and remodeling of these shops a necessity. In 1914, therefore, the government decided to make the improvements and extensions, and adopted the recommendation of Director Roelofsen that they be electrically equipped throughout. Previous to this time the available water power of the Tji Tjatoer had been fully investigated, and work on the project was started. Since March, 1917, this station has been in continuous operation, and may be briefly described as follows:

The Madiun plant generates current at 6,300 volts, transformed to 26,000 volts for transmission to town. The transmission line is seventeen miles in length, and the steel towers, which are 128 feet apart, are arranged to carry two 3-phase circuits. The net head, after deducting all losses, is about 100 meters, and the entire plant is capable of supplying 2,000 H. P. from two turbines when sufficient water is available. Six years of observation and stream gaging have determined that the full capacity of the turbines could be relied upon for but 6½ months in an average year; and the station is now operating under these conditions. The department, however, expects to augment the capacity of the plant at some future date so that 2,000 H. P. may be delivered continuously the year round. It has not yet been determined, however, whether this will be done by installing a steam auxiliary or by building storage reservoirs farther upstream. At present, power is supplied only to the railway shops. As soon as the maximum current of 2,000 H. P. is available throughout the year, the City of Madiun will be provided with electricity for lighting.

One of the problems in designing water-power plants in Java is that of silt and gravel which these mountain streams carry in their tumultuous course. This has been solved on the Tjatoer, and at the other plants, by building sedimentation reservoirs where the velocity of the water is checked and the sediment is allowed to settle. From thence it can be readily removed.

TYPICAL SCENES IN JAVA THE GARDEN SPOT OF THE DUTCH EAST INDIES



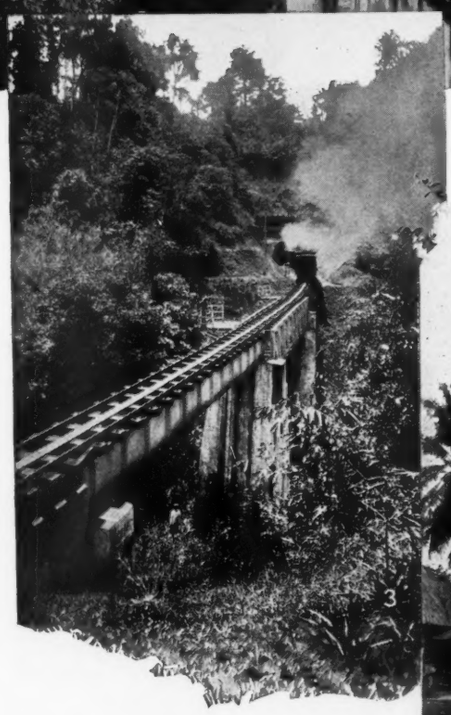
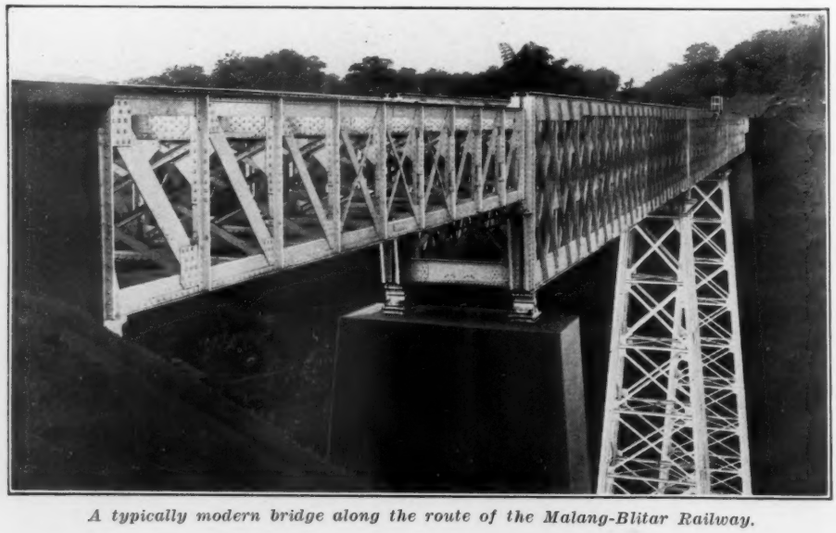


Fig. 1—Railroad near Padalarang. Fig. 2—A section of the steam line which traverses the Preanger Regency. Fig. 3—A tunnel along the right of way of the railroad in the Preanger Regency. Fig. 4—A Typical native village. Fig. 5—A fine steel railway span near Krawang. Fig. 6—A panoramic view from the Hotel Bellevue at Buitenzorg.

A concession has been granted to the General Netherlands Indian Electric Company and construction has been begun by them on a hydro-electric plant of 2,200 kilowatt capacity at the falls of the Tji Toentang south of Samarang, the purpose being to supply that city and Salatiga with light and power. This company has further plans which include power developments and irrigation projects on the Rawa Pening, near Ambarawa.

In addition to the plants described there are many small water-power installations in Java which are owned and operated by private companies. These are principally found in the western part of the island and supply energy for various factory and agricultural purposes. Some of these power plants have been in operation 60 or 70 years, and there may still be seen many of the old wooden abreast and undershot wheels, attaining at times a diameter of 30 feet, with direct engine coupling used to drive rubber, tea, and coffee machinery, and rice hullers. Gradually, however, these ancient and inefficient wheels are being supplanted by modern turbines. In all, there are said to be about 160 of these small plants. In re-equipping them, a standardized plan has been largely adopted so that, when the general scheme for the expansion of the use of electricity on the island of Java is completed, these power plants will fit properly into the system.

The aforementioned constitute about all the developed hydro-electric plants and those under construction in Java. The government, however, in connection with private enterprise, has ambitious plans for the immediate future which include the installation of 18,600 H. P. in light units at different points in the Tji Mandiri territory; 43,700 H. P. at ten sites on the Tji Sangkoeg; 31,500 H. P. in four units on the Tji Laki; and 30,100 H. P. at seven



A typically modern bridge along the route of the Malang-Blitar Railway.

places in the Tji Manoek territory. In these four districts, which are in the west, there will ultimately be provided 123,900 H. P.—equal to about a quarter of Java's potential development. These stations, as well as projected and well-designed plants in central and eastern Java, will be constructed and utilized primarily for generating power to operate the railways; but it is believed that there will be sufficient energy remaining to supply current for many other uses—industrial and municipal.

Java is justly proud of its railway system and of the fact that it is apparently going to be the first tropical Asiatic country to modernize it by the introduction of electric traction. The local government is proud, too, that it has been able to work out the financial questions in connection with the electrification without the aid of the home government.

The railways of Sumatra, Borneo, and Celebes have not yet assumed an importance which justifies electrification. When they do, however, ample water power awaits them. The power possibilities of south Sumatra are so great that it has been suggested developing some of the sources and transmitting the current to Java under the narrow Strait of Sunda—about eighteen miles wide—which separates these two islands. Sumatra has a considerable number of small hydro-electric plants at work. These vary from several hundred to 3,000 or 4,000 H. P., and are used, largely, to supply power for mining and agricultural operations.

In regard to the Island of Celebes, which is credited with a potential 1,000,000 H. P., it was stated last year that the famous Nitrate Syndicate had received a concession to develop water power there and that it would shortly erect a 200,000-H. P. plant for the manufacture of fixed nitrogen and metallurgical products.

Paddy fields in the Preanger Regency. Rice is the staff of life in the Far East.

ROAD-MATERIAL SURVEY AIDS HIGHWAY CONTRACTOR

THE STATE of Colorado possesses a wealth of the best road-building rock that can be readily developed and used. In order to facilitate road construction, there has been organized a so-called Road Materials Survey, conducted by the Colorado Highway Department in coöperation with the State Agricultural College. It is the work of this Survey to locate the material and to record the data as an aid to contractors in selecting the pit best suited to a particular road-building job and in making an estimate thereon.

Since the Survey started activities in 1921, much of the state has been covered, and 260 pits, representing an available supply of about 9,000,000 cubic yards of material, have been sampled and reported upon. The field work is conducted as follows: first, the object is to prospect a given area. If there are signs of gravel or rock, test holes are dug to determine the character and the extent of the deposit. If the material appears to be acceptable, and if the deposit seems to be of a size to warrant it, samples are taken and a plane-table sketch of the area is made. The samples are then sent to the Road Materials Laboratory at Fort Collins, Colo.

A pit report is finally made, copies of which are submitted to both the Highway Department and the Testing Engineer at the College. This document tells all about the type of material, location, extent, quantity available, character and amount of stripping, haul to the nearest highway and shipping point, proposed use of material, initial cost, current hauling cost, etc., in brief, all the details that a contractor needs to make his estimates on construction jobs. The work of the Survey is of outstanding importance in planning highway improvements in the State of Colorado apart from the aid it gives to road builders.

Pneumatic Sweeping Lessens Dangers of Industrial Dust

Dusts of Some Sorts are Explosive and They Must Be Removed to Prevent Possible Disaster

BY SIDNEY MORNINGTON

THE INDUSTRIAL world is gradually awakening to the fact that seemingly harmless dust is capable of doing a vast deal of violently destructive work. In short, dusts of various sorts can, under favorable circumstances, destroy and damage much like a blast of gunpowder.

Recognizing this menace, the engineering fraternity has devised during the last ten years or more dust-removal equipment which have unquestionably lessened the hazard of dust explosions. But most of these corrective efforts have been directed towards carrying off the floating dust which polluted the atmosphere while comparatively little has been done to dispose of deposited or "static" dust—the idea, apparently, being that the settled dust was not a cause for alarm.

This attitude towards dust has been a faulty one, because it did not take into account the indubitable fact that the quiescent dust might easily be disturbed and turned into a cloud of floating dust with all of the potentialities of a powerful explosive. In short, the fundamental principles of this problem, which touches so many phases of industrial life, have been imperfectly grasped or but little understood by the people intimately concerned with the possible conversion of a seemingly harmless substance into one capable of exerting a tremendous destructive energy.

The United States Department of Agriculture has done a great deal of educational work in the last nine or ten years in an effort to point out the importance of properly controlling dusts of different kinds lest explosions of these materials lead to loss of life, loss of property, loss of food, and loss of employment. In this campaign of enlightenment, David J. Price, an engineer of the Bureau of Chemistry, has been conspicuous, and this expert has presented his subject in a clear and readily understandable manner.

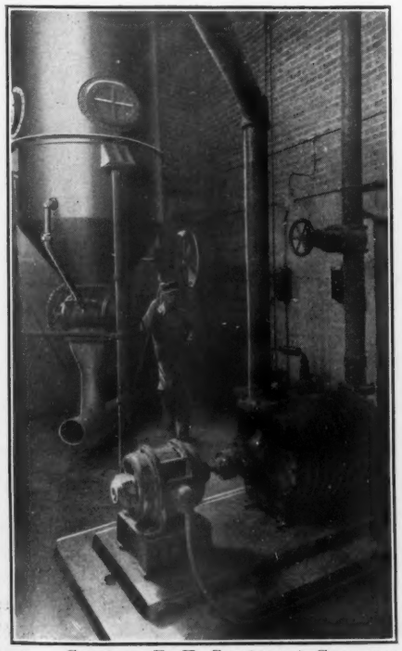
It is an error to assume that dust explodes in the same manner as high explosives, that, for instance, a sack of flour or a package of starch in the kitchen cabinet might suddenly blow up like so much gunpowder. This is not the case, for dust explodes in substantially the same way as gas does. That is to say, gas and air must be mixed in the proper proportions to make the gas explosive, and, in a similar manner, dust must be intimately mixed with sufficient air to render it explosive. But neither the mixture of gas and air nor the mixture of dust and air will explode unless it is ignited by a flame or sufficient heat.

The evolution of a dust explosion may be reduced to very simple terms. Each particle of combustible dust, when burning while afloat in the atmosphere, heats rapidly and to a high temperature an envelope of air immediately surrounding it. The air thus heated expands and exerts force, and where many millions of particles are concerned it is easy to realize that the aggregate outward movement or energy may be strong enough to shatter walls, to blow off a roof, and to do other structural damage.

Experiments conducted by the United States Bureau of Mines have revealed that two ounces or more of fine coal dust in a cubic yard of air will make an explosive mixture, and there is reason to believe that the proportion is not greatly different for dry organic dusts in general. By way of illustration, let us consider starch dust, and assume that two ounces of it are floating about in a cubic yard of free air. In burning, two ounces of starch will give out about 950 heat units; and one heat unit is theoretically capable of producing the mechanical equivalent of raising a weight of one pound to a height of 772 feet. If we assume that only 10 per cent. of the heat generated is converted into mechanical work, then the dust exploding in a cubic yard of air will exert a force equivalent to 73,340 foot-pounds! As has been said, "A million foot-pounds of mechanical energy, available for the destruction of a building, could, therefore, be developed in a room of very ordinary dimensions."

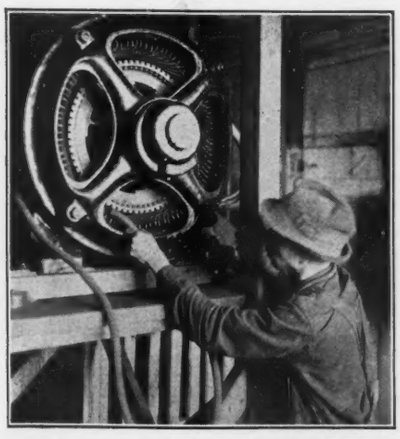
While dust explosions have taken place with greater frequency in plants handling grain or grain products, still destructive explosions have also occurred in sugar refineries, cocoa and chocolate plants, spice works, candy factories, woodworking establishments, fertilizer works, cork-grinding plants, and other places where industrial dusts are produced. Indeed, explosions have happened where aluminum, magnesium, and hard-rubber dusts were ignited accidentally. This recital gives a hint of the widespread character of the menace latent in inflammable dusts.

To avoid confusion, we shall confine the present treatment of this vital subject to a consideration of grain-dust explosions, and this will probably cover enough of the general topic to make it clear how essential it is that dust should not be allowed to accumulate in

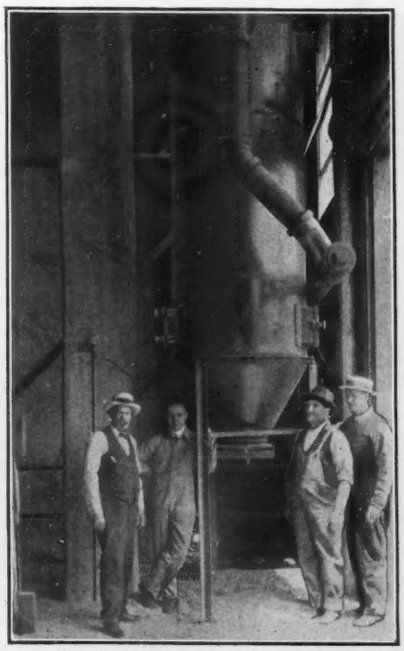


Courtesy B. F. Sturtevant Company.

One of the dust-filter tanks now installed in the renovated Northwestern Elevator.



Cleaning one of the numerous electric motors in a large plant by means of compressed air.



Courtesy B. F. Sturtevant Company.

A multi-stage, centrifugal, vacuum-producing unit with a large dust-filter tank in the background.

dangerous quantities. Incidentally, we shall outline what are the latest means available for the rapid and effectual disposal of industrial dusts.

Investigators have not yet ascertained what is the minimum quantity of grain dust which must be afloat in the air before an explosion can be started. However, it is fairly well established that grain dusts are more inflammable than coal dust, and, therefore, it can be assumed that the density of a cloud of grain dust need not be any greater than that of a cloud of coal dust which will propagate an explosion. The Bureau of Mines has found that 0.0253 ounce of coal dust per cubic foot of air is sufficient to induce an explosion.

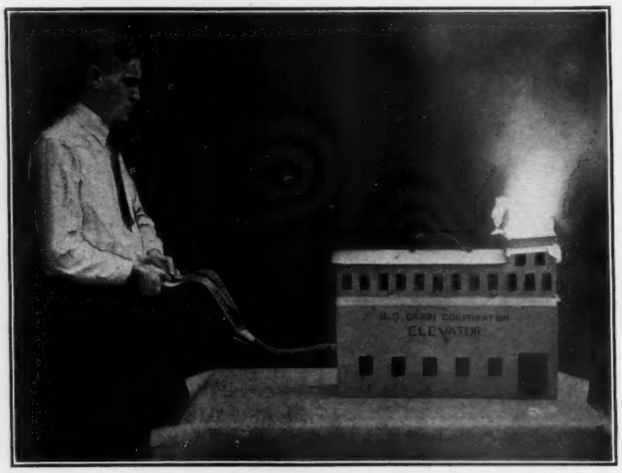
Research has also brought to light that the explosive pressure, according to the nature of the dust, may range from 5 to 16.5 pounds per square inch at the instant of explosion; and the pressures increase in the case of any dust according to its relative dryness—the increment varying from ½ pound to 8 pounds per square inch. Therefore, atmospheric conditions may tend to add measurably to the violence of a dust explosion.

In the tests, which gave the pressures cited, .00176 ounce of dust was suspended in 85.36 cubic inches of air. In order to obtain the same proportion of dust and air, it would be necessary to have only 10 pounds of the dust floating about in a closed room containing 4,466 cubic feet—that is, a chamber 30 feet long, 15 feet wide, and 10 feet high. That mixture would, undoubtedly, be dangerous, and the presence of a larger measure of dust would augment the hazard. For those unfamiliar with this subject, it may be said that .00176 ounce of dust in 85.36 cubic inches of air represents a dusty state which might well be described as moderate in view of the atmosphere often prevalent in grain elevators and in other plants engaged in handling or working up grain into food products.

Perhaps it might be well to point out here that it is not necessary to bring most dusts in contact with a considerable source of heat in order to ignite them, such, for instance, as an open flame or the very high temperature of an electric arc. As a matter of fact, numerous explosions have been caused by a chance spark given off by foreign materials passing through or striking mill machinery. Again, the discharge of static electricity, induced by friction, has been responsible for many dust explosions. Some dusts will ignite when they touch bodies having a temperature of only 1.004°F. —a temperature which is well below dull-red heat; and most of them will take fire when exposed to temperature of 1,112°F.

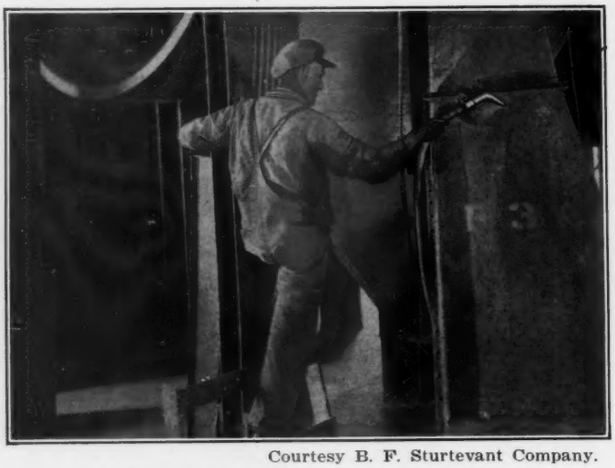
While explosions, as a rule, are propagated with greater velocity through most gas mixtures than through most dust clouds, still in some cases the velocity of flame propagation in coal-dust explosions has been found to exceed the maximum for certain gases. Again, the velocity through a cloud of wheat-flour dust was determined to be substantially the same as that through coal dust; and the speed of propagation through a cloud of powdered starch was ascertained to be several times faster than that through coal dust. All of this tends to emphasize the potentialities for harm latent in dusts.

When a plant is damaged or destroyed by a dust explosion there are commonly two or more reports, indicating a succession of explosions; and the first report is usually a sharp one followed by one or more of a loud, thundering nature and of longer duration. The second report is apt to be followed by fire, which may wipe out the plant and spread to neighboring property. The primary explosion is due to the ignition of a small quantity of fine, floating dust. The resultant concussion disturbs the dust that has settled on adjacent surfaces, and, as the latter is shaken loose, another dust cloud is created, and this explosive mixture is ignited in its turn. Thus, a series of explosions may be propagated throughout a



Courtesy U. S. Department of Agriculture.

A dust explosion produced at will to demonstrate what takes place when dust meets an open flame.



Courtesy B. F. Sturtevant Company.

A handy, small suction nozzle can be used to remove dust from ledges, overhead piping, etc.

Courtesy B. F. Sturtevant Company.

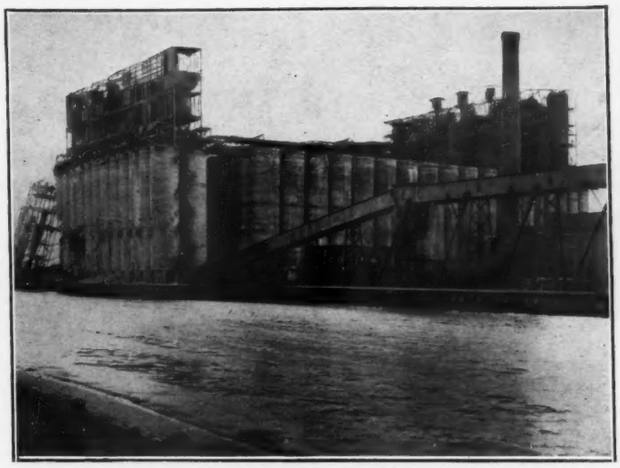
Removing grain dust from upturned surfaces in comparatively inaccessible parts of an elevator plant.

Courtesy B. F. Sturtevant Company.

The pneumatic sweeping system is capable of handling effectively accumulations of grain and chaff as well as dust.

large area and, perhaps, gather violence as more and more dust is inflamed. Manifestly, it is necessary, in the name of security to life and property, that means be employed regularly and thoroughly to dispose of both dust in suspension and deposited dust.

Now, let us cite one outstanding example of the explosibility of grain dust and describe what has since been done towards introducing a new system to minimize the risk in that particular establishment. In 1914, the Chicago & Northwestern Railroad Company began the construction on the west bank of the Calumet River, in Chicago, of a gigantic elevator capable of housing 10,000,000 bushels of grain. When completed, the plant represented an outlay of fully $10,000,000, and, architecturally, was a monumental example of what could be done with steel and concrete. The central part consisted of 182 concrete bins, each 104 feet high and with an internal diameter of 22 feet.



A view of the Northwestern grain elevator, with its 182 big concrete bins, taken after the disaster from across the Calumet River.

Mr. Price has thus described the equipment provided in that plant for the disposal of dust—an installation which was considered ample at the time and then typical of the state of the art. "The dust-collecting system for the house consisted of an expansion chamber, cyclone collectors, and the necessary fans to blow the dust to the collectors and to convey it, after it had settled, to the dust house—a concrete building 106x28 feet located about 194 feet south of the working house. The large expansion chamber and 40 cyclones, located between the working house and the storage section, received the dust from the cleaners and the floor sweeps. Eight floor sweeps were installed in the basement and eight on the first floor, while the cupola was supplied with sixteen. The expansion chamber contained six vent stacks which extended above the roof level of the storage section. The dust discharged by the cyclone was blown by fans, located in the working house, to two large cyclones on the roof of the dust-sacking house. These cyclones discharged the dust to eight Monitor dust packers, which sacked the dust for shipment. While this collecting system provided for the removal of dust from the cleaning machines and the dust swept up on the floor when the plant was being cleaned, no arrangement was provided or permitted by which the grain on entering the house could be cleaned, nor was suction applied on the elevators or the conveyors."

About six o'clock on the evening of March 19, 1921, there was an explosion within the Northwestern Elevator which seriously damaged some parts of it and completely destroyed other sections. The total loss in grain and in property amounted to $3,750,000, and six lives were sacrificed—happily the catastrophe occurred when the plant was almost deserted. There were at least two separate explosions, the second and heavier one taking place about ten seconds after the first one. The concussion was sufficient to break windows in business buildings and residences five miles away; and persons 100 miles distant reported that they heard the explosion. The violence of the final blast sufficed to demolish a considerable portion of the southeast corner of the storage house; and the manner in which sturdy walls of concrete were burst asunder and steelwork was twisted into tangled masses plainly indicated the magnitude of the strength of the pent-up, highly heated gases which sought escape.

The lower ends of some of the shattered grain bins in which many thousands of bushels of wheat were stored before the blast occurred.

How the large concrete grain bins at the southeastern corner of the Chicago and Northwestern Elevator looked after the explosion.

Courtesy U. S. Department of Agriculture.

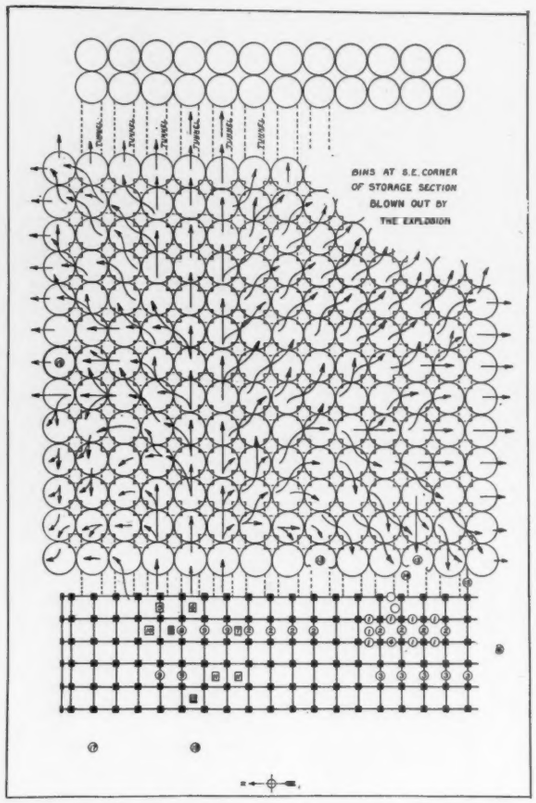
Fighting fire following a dust explosion in a grain elevator.

Following that disaster, the owners of the property rehabilitated the elevator and equipped it with a new system of pneumatic sweeping which is designed primarily to dispose of static dust with reasonable rapidity so that the major element of explosive hazard may be done away with. Mr. F. C. Allen, Jr., who has figured in the designing of the improved dust-removing installation, has furnished the details which follow. The usual practice in removing accumulations of static

dust is to sweep the floors with brooms or to brush the dust down from other parts of a building and deal with it a second time after it has reached the floor. In cleaning the floors of a grain elevator, where large quantities of dust gather, it is not possible to do the sweeping with ordinary brooms or brushes without raising great clouds of dust which must again settle—no matter how many times this procedure is followed. And because of the nature of the commodity handled in a grain elevator, the workers are not permitted to sprinkle the floor in order to check the scattering of dust.

The improved pneumatic sweeping system is virtually an application of the familiar vacuum cleaner but utilized on a far more pretentious scale; and a number of the accompanying photographs illustrate the actual operation of this novel equipment as now installed in the Chicago & Northwestern Elevator. As will be seen, nozzles of different types are employed to deal with the dust according to the character of the floor or other surfaces upon which the dust is deposited. No dust is raised during the sweeping process; and it is claimed that surfaces are cleaned so thoroughly that they appear as if scrubbed with soap and water. Inasmuch as the suction operates during both the forward and the backward strokes of the nozzle, the dust-removal action is continuous. As we know, a broom is effective in only one direction. The pneumatic sweeping system not only dislodges dust but carries it off at the same time; and the suction is powerful enough to withdraw dust from cracks, crevices, and other places which are fairly inaccessible to the ordinary cleaning facilities. The bodily effort called for on the part of the operator is far less than that demanded by a man using a broom.

Where dust-collecting systems of the rather common low-pressure type are installed, the dust is drawn through the fan or exhauster and then blown onward through some sort of a dust collector. In the case of the pneumatic-sweeping equipment placed in the Chicago & Northwestern Elevator it was necessary to provide a way to sidestep the dust and to separate it from the air before the latter reached the somewhat mechanically refined, centrifugal, vacuum-producing units. In other words, a comparatively high vacuum is maintained—to be specific about eleven inches of mercury, and it is therefore necessary that the exhauster be kept clean and in a condition to work efficiently.



A graphic illustration of the manner in which the explosion in the Northwestern Elevator at South Chicago was propagated and how its destructive forces traveled. The circles indicate positions of the grain storage bins, and the rectangles indicate various parts of the workhouse section of the plant. The associate numbers indicate places where structural damage was done.

The exhauster units are four in number, each consisting of a Sturtevant multi-stage centrifugal operated by a 20-H. P. electric motor. The intake or suction ends of these vacuum producers are connected with a number of large dust-filter tanks which are linked with more than two miles of piping running to the various parts of the grain elevator. The latter pipes, in their turn, are fitted with numerous couplings which afford means by which suitable lengths of hose, equipped with sweeping nozzles, can be attached to the suction lines.

Inasmuch as the system is called upon to handle great quantities of dust daily, amounting to a number of carloads, it has been necessary to provide special collectors or filter tanks which would evacuate themselves continuously. This is accomplished by mechanically operated discharge locks—one at the bottom of each tank—which dump the dust at regular intervals without admitting the outside air and thus lowering the operative vacuum. The dust so discharged is immediately picked up by the auxiliary low-pressure-air conveying system which blows the dust onward and carries it from the elevator to an outlying dust house located some distance away. The filters are so arranged that any loose grain picked up by the sweepers is separated from the dust and reclaimed.

While the foregoing system answers excellently for the work required of it in the removal of bulk dust, experience has disclosed that suction is not always the most effective means by which to withdraw dirt or dust from various intricate or fairly complicated industrial mechanisms which must be cleaned from time to time. For the latter service, compressed air is peculiarly suitable, and its adaptation in this department of usefulness is steadily widening. Let us be specific.

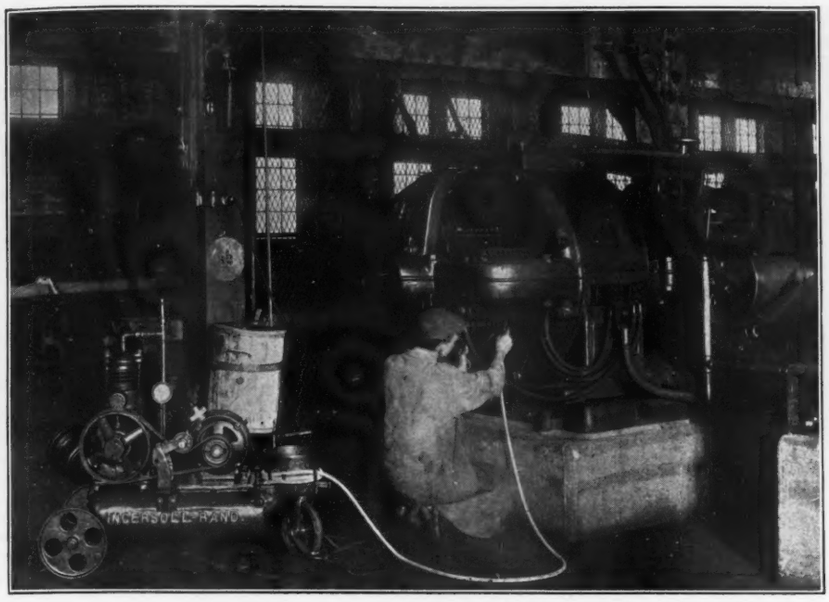
Dust in electric motors, for example, is apt to be extremely troublesome and responsible for heavy outlays in some establishments in the course of a twelvemonth. This is not hard to understand. Dust induces excessive wear, leads to unreliable operation, and sooner or later causes the burning out of motor windings. To prevent the intrusion and the accumulation of dust in motors, one very large electric company developed a totally enclosed, self-ventilating type; but while that make of motors was, for all practical purposes, substantially dustproof still other objectionable conditions were created owing to the consequent inaccessibility of the machines. As a result, the closed

Courtesy U. S. Department of Agriculture.

A black cloud of smut dust issuing from the blower pipe during the threshing of smutty wheat in a northwestern state.

Courtesy U. S. Department of Agriculture.

The remains of a threshing outfit after the explosion of smut dust in the open.



A portable compressor, which can conveniently be shifted from point to point, providing air for the cleaning of dynamos, motors, and other complicated machines.

casing was abandoned, and compressed air is now employed instead in effectually blowing out dust and keeping the motors clean.

In flour mills, grain elevators, and other plants where the dust is of an explosive character, the gravity of a dust-coated motor is intensified, because the burning out of the motor may promote an explosion and, possibly, the destruction of the establishment. It is authoritatively stated that a single flour mill, equipped with a large number of motors, was spending fully $5,000 annually for armature up-keep, which was directly due to the effects of grain dust. The management installed an air compressor, ran piping therefrom around the plant, and "blew out" the machines with compressed air at frequent intervals. In the course of the following year there was not one instance of a motor burning out by reason of dust. There are many industries in which a similar protective service would pay for itself in a reasonably short period.

In conclusion, it may be justly said that the art of pneumatic sweeping or cleaning is in a state of flux and is undergoing rapid improvement and evolution. As the gospel of dust suppression or dust removal spreads the broom is steadily giving way to a pneumatic system of one sort or another, depending upon the nature of the problem to be attacked.

The State of Missouri is active and prosperous in the manufacture of pneumatic apparatus—the value of the corncob pipes produced in 1922 was close to $1,000,000.

Brass mail-collection boxes are being placed by the Post Office Department along the boardwalk at Atlantic City, replacing the iron ones and avoiding the cost of maintaining them. The boxes rust so rapidly that some of them have to be replaced in three months. Might this not be a good place to try the new rustless iron?

ELECTRICITY'S NEW ROLE —THE HUMBLE TOWEL

WE HAVE had Turkish towels, cotton towels, linen towels, silk towels, and paper towels—but unsatisfactory features have attended each in turn. Now comes the electric towel, the last of a large family and, probably, the most economical because it isn't a towel at all, but just a machine that dries the hands and face by evaporation.

The thing is simple. Contained in an enameled-iron stand, as shown in the illustration, is a 1-kilowatt motor, a fan, and a little heating coil, which warms the air as it passes. Wired from the nearest panel-box, the installation is complete.

The ultimate saving is apparent inasmuch as the first cost is the only cost except for the current. There is neither up-keep nor laundry expense to be considered. It appeals to us because all one has to do is to step on a pedal and, zip, hot air does the rest—and the operation takes just a few seconds.

One of the advantages of the electric towel is that no one touches what has been used by another. In the case of the ordinary towel who knows where it was last week or to what use it was being put? The air towel is, of course, sanitary. The air that dries one pair of hands is God's air—the air we breathe—and is never used again. Infectious diseases cannot be communicated from one person to another because there is nothing material to carry them.

It has been demonstrated that evaporation is a perfect drier. The manufacturers of the electric towel claim that it serves not only to prevent chapped hands but that it is an actual cure for chapped and sore skin, as the hot air penetrates so deeply into the pores that it brings up the natural oil of the skin leaving it soft and smooth.

The electric towel is only three or four years old but, from the number of installations already made in big establishments, the idea seems to be a "taking" one. The strong plea is sanitation. An equally strong endorsement, however, is economy. By its adoption, there is said to be a saving in towel expense in large stores, offices, and the like of anywhere from 50 to 85 per cent.—a claim that appears reasonable, based on the figures of actual performances "before" and "after" using. The following is a summary of figures representing the experience of a big department store in Brooklyn, N. Y., employing 4,500 persons, that tried out the old and the new towel services.

First Cost		
Cloth towel equipment, life of towel one year		$2,700
Electric towel equipment, life unlimited		6,581
Annual Operating Cost		
Laundering towels	$8,100	
Depreciation, 100 per cent.	2,700	
Interest	162	
Total		$10,962
Electric current	$1,014	
Depreciation, 10 per cent.	658	
Interest	395	
Total		2,067
Total annual saving.		$8,895

A prominent American exporter has found that a coat of shellac effectively prevents stencil marks on packing cases from rubbing, blotting, and becoming obliterated in transit.

Tokyo, Japan, with a population of 5,164,000, is now the third largest city in the world.

Pressing the pedal in the base of the apparatus releases a stream of warm air which quickly dries the hands.

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—*Founded* 1896—

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EDITORIALS

PURE RUBBER PROMISED BY SPRAYING PROCESS

RUBBER figures intimately in so many departments of life, and America's manufacture of rubber commodities so far outstrips the kindred activities of any other nation, that an improvement in the working up of rubber must, therefore, concern millions of people.

The United States Rubber Company has lately described a notable step forward in the manufacture of rubber which its experts have achieved in the development of what is termed "sprayed rubber."

Sprayed rubber, so it seems, is the outcome of a new method of producing crude rubber from the original latex, and the process insures for the first time, it is asserted, a pure and absolutely uniform material. Hitherto, all rubber produced and marketed has been coagulated by treating rubber latex either with smoke or chemicals. The conditions under which this treatment has been conducted first in the forest and afterwards in a plant have all too often failed to yield a commodity of a satisfactory or reasonably uniform quality.

When rubber is made by treating latex with acetic acid, the resultant rubber not infrequently contains acid residues. Furthermore, the acid tends to destroy some of the valuable natural properties of the latex. The new process sprays the latex in the form of a snow-white mist and brings this finely atomized fluid in contact with clean, superheated air—thus evaporating the water content of the latex without making any other change.

We are informed that sprayed rubber is 100 per cent. pure; that it has greater strength than the ordinary commercial rubber because it contains all the natural properties of the original latex; and that the rubber is, therefore, unimpaired by chemicals or the destructive effect of machine working. In short, the rubber produced by the new process is virtually revolutionary because of its superior qualities.

SAFETY CONDITIONS IGNORED

"PROMISES," as they flippantly say, "like pie crusts, are made to be broken," and compressed air precautionary regulations would seem to be in the same category. *California Safety News* for March tells of an explosion of a small air receiver under peculiarly exasperating conditions.

The adapted air receiver was an old, vertical, water-range boiler, twenty inches in diameter, top head concave to pressure and bottom head convex to pressure. The pressure that would have been allowed on this tank under "Air Tank Pressure Safety Orders" was 63 pounds. A pressure gage and a safety valve were installed on the tank. It is not known what pressure the valve was set at, and it does not appear that anyone had ever known it to blow.

Air was supplied by a motor-driven compressor without automatic shut-off, and the compressor had no unloader. The motor would be started by hand, and when the pressure got up to about 110 it was stopped by hand. The compressor was designed for 75 pounds and, according to catalogue, required 7 H.P. It was necessary at times for the operator to be out of the room, and it was when he was absent that the explosion occurred. The bottom head was blown out and the tank went vertically through the roof, landing about 140 feet away. There was no discoverable defect of material. The dishing of the head was reversed; and of the 102 rivets only six were not sheared. We might say that if an explosion was intended everything was well planned.

TEN-THOUSAND-DOLLAR MAN WANTED

SUCH was the title of a preachment by EDWARD S. JORDAN, president of a well-known motor company, which appeared a short while back in *Trade Winds*. Many men are anxious to be in the ten-thousand-dollar-salary class, but comparatively few of them seem capable of realizing their ambition.

Mr. JORDAN points the way to reach the goal, and as his instructions are clear and forceful, let us quote him:

"Somewhere in this town there is a young man who would like to make ten thousand dollars a year. I can tell him exactly how to do it providing he understands the English language, can speak it fairly well, is not suffering from paralysis of the legs, and really wants to make ten thousand dollars a year.

"First, there are three fundamentals which he must fix definitely in his mind. One has to do with the three letters—A, B, and C.

"When I finished college after many years of alleged education I thought these letters stood for three words—Always Be Clever.

"After seventeen years of being kicked around the universe I have discovered that they really stand for something else—if you will permit a play upon the last letter—Always Be Simple.

"The second fundamental is this—two plus two makes four.

"Now if this young man who wants to make ten thousand dollars a year will recall the copy book in which he learned to write, there will come into his mind the very first phrase—'Honesty is the Best Policy.'

"Now with these things in mind this young man should remember that if you put one penny in the bank today and decide to increase your deposit by geometrical progression each day for one week, you will discover that on the seventh day you have something over forty million dollars in the bank.

"Now, if instead of depositing one penny in the bank each day you think of depositing one good selling idea in another person's mind, and you make that idea so interesting that he will deposit it in the minds of two other persons on the following day—then, by geometrical progression, that idea will travel at a very interesting rate of speed."

UNIFICATION OF ELECTRIC SYSTEMS

PEOPLE at large are unaware of it, but a superpower zone for America's greatest manufacturing section is gradually becoming an accomplished fact without any fuss or parade.

It will be recalled that the United States Geological Survey, after a year or more of work, made a report upon the practicability of establishing a number of master power stations and of interlinking those proposed power plants and the existing first-class central stations by a network of transmission lines which would virtually bind Boston and Washington electrically. The findings of the experts made it clear that many million tons of coal could thus be saved annually and other economies effected that would be well worth while.

The scheme, as a whole, was of magnificent proportions; but it was generally recognized that there was little likelihood of the plan in its entirety being taken in hand in the immediate future. However, the authoritative data made public by the superpower survey have, undoubtedly, given an impetus to the development of hydro-electric and steam-electric power plants and to the extension and interconnection of many transmission systems not only within the Washington-Boston area but also within other industrial sections of the country.

A notable example of this trend has been disclosed recently by the Empire State Gas & Electric Association which has announced the nearing completion of a transmission line which will join the power resources of the Northern New York Utilities with those of the Utica Gas & Electric Company. According to the Association, the 4,000 miles of wire involved in this arrangement is capable of providing half the industrial power used in New

York State and of furnishing current for numerous trolley systems. Electricity generated at Niagara Falls, in the Adirondacks, and on the Hudson and the Mohawk Rivers will be made available as far south as Newburgh.

The advantages accruing from this interconnecting are thus described: The interchange of power should assure steady supplies of electricity to those parts of the state within reach of the system. Breakdowns in one town or district can be offset or nullified by switching in the power generated in another town or district. When a water-power plant drops in its current output during seasons of low water, the needs of its customers can be satisfied by coal-burning power stations located where ample fuel is at hand.

The *New York Sun*, commenting upon this development, remarks editorially: "Electrical power is thus rather a state than a local affair, since a company or a group of related companies serves many towns at once. The gain in a steady supply and more extensive transmission of electrical power should be reflected in reduced hitches in production in the industries using it, in steadier operation of street railways, as well as in more advantageous rates for the household consumer. The public should profit in many indirect ways. The electric companies should gain in favor by becoming the servants of a great part of the state rather than of a group of special districts."

INCREASED IMPORTS DESPITE THE HIGH TARIFF

ATTEMPTS have been made, following the enactment of the Fordney tariff, to make political capital out of the increase in imports into the United States. It is interesting, therefore, to analyze these imports and to see how far they are affected by the industrial prosperity which exists in the United States.

The Department of Commerce, in its official bulletins, has given us such an analysis; and the latter shows that for the seven months ending January, 1923, as compared with the seven months ending January, 1922, the largest increase in imports was in "Crude Materials for Use in Manufacturing." In 1921, this item constituted 35 per cent. of the total imports, while for the same period in 1922 it amounted to 39 per cent.

The next largest percentage of our imports is shown under the item "Manufactures Ready for Consumption." In the seven months ending December 31, 1921, this item represented 26 per cent. of all the imports while for the same period in 1922 the percentage is 20, thus showing that in actual manufactured products, ready for use, the percentage of our imports has fallen off.

The third largest item tabulated is "Manufactures for Further Use in Manufacturing." In this case the percentage for 1921 is 14, as against 19 in 1922.

Obviously, the percentage basis is a better guide than the actual figures, because every one knows that in 1922 and 1923 prices have increased over 1921; and the significant fact brought out by these official figures is that the increase in our imports reflects increased industrial activity in America.

In the matter of exports, the official figures of the Department of Commerce for the eight months ending February, 1923, indicate that there was a slight increase in the totals over those for the same period in the previous year. This slight increase is also shown in the percentage of "Manufactures Ready for Consumption." In the eight months terminating February, 1922, this item was 31 per cent., while for the same period in 1922-1923 it reached 33 per cent. In the exportation of foodstuffs there has been a big falling off both in volume and in percentage.

MOTH-PROOF WOOL

AND NOW, crowding closely upon the production of stainless steel, we have moth-proof wool. It seems to be chiefly the discovery of Dr. ERNST MECKBACH, who writes about it in *Die Umschau*, Frankfurt. He says that he was led to the special research by the frequently expressed belief of old housewives that "moths won't touch green cloth."

In the beginning of his experiments he found the moths ate green stuff of recent production as eagerly as any other woolen goods; but he also discovered that green cloth dyed 50 years ago is actually moth proof. The green dye then used was a blue-yellow, and it was the yellow to which the moths objected. This was the well-known "Martins Yellow"—one of the first of the artificial dyes made from coal tar.

Following this hint, a chemical has been prepared which is perfectly effective for the protection of all woolens. The goods are placed in a cold solution of the chemical until thoroughly saturated. Next, the stuff is taken out, hung up for several hours, rinsed with fresh water, and dried. A few strands of treated and of untreated wool were put in two test tubes within which moth eggs were then placed. Six months later tube A, containing the untreated wool, was quite empty except for the excrement and pupa cases of the larvae, while tube B held the woolen contents intact plus the corpses of the larvae, which had starved to death upon issuing from the eggs.

THE INVENTIVE EQUIPMENT

INVENTORS, and especially pseudo-inventors, are as numerous and as active in compressed air lines as in any other activity. The schemes which are submitted to us for advice and criticism, or more frequently for our approval and endorsement, are too numerous to mention. Often the propositions submitted do not involve actual inventions at all. Something has been thought of, to be done and there the invention ends. We are asked to tell in detail how it is to be done; and if we could supply the needed instruction our correspondent would assume that he was responsible for the invention, and would think about a patent and the wealth inevitably to follow.

To tactfully turn down all these is no easy task, and, when the decision is not encouraging, it is often immediately assumed that we are prejudiced and that our opinion is, therefore, worthless. So we get no thanks for our frankness.

In the matter of alleged new inventions we certainly are prejudiced. We are aware that successful inventions are begotten almost entirely by those who know the most and not by those who know the least—or nothing at all—about what has been done; is being done; what is intelligently being planned in the way of means and methods; and about the results sought. When we are approached by those who know little or nothing of these things, and who are wofully ignorant of the elementary principles of physics and of mechanics, our prejudices become strongly assertive.

To explain to these poor unfortunates why their inventions will not work is practically impossible. We have tried it over and over, never with success, and have practically given it up. Life is too short. Generally, a full course of kindergarten instruction is called for, to begin with, and from that on upward. These good people whom we have in mind apparently never actually experiment: they seem to do nothing but theorize without computation or comparison of means and results.

All this is by no means for the discouragement of the would-be inventor, but quite the reverse. His opportunities multiply and broaden continually; and the prospective rewards were never greater. The key to success is now, as ever, complete and up-to-date information with critical and exhaustive experiment where necessary; and, perhaps, abnormal foresight to supplement the "hindsight." The true and fully equipped, successful inventor knows what he has and its value, and he becomes at once our instructor instead of the reverse. R.

FACTS AND FIGURES ON AMERICA'S ECONOMIC STATUS

THE President of the Chamber of Commerce of the United States, Mr. JULIUS H. BARNES, has recently returned from Europe, and has presented some facts and figures bearing upon the economic condition of America which are worthy of special notice.

Between 1913 and 1922 our population has increased from 95,000,000 to 110,000,000, an increase of 15,000,000 people whose normal requirements and expansion of living must be supplied.

"Our annual national income has increased in that period from $33,000,000,000 to $50,000,000,000, with all that portends of enlarged human consumption and buying power.

"Our savings accounts have increased from $4,750,000,000 to $7,250,000,000, with all that holds out of reward for self-denial.

"The national bank balances have increased from $6,000,000,000 to $16,000,000,000, with all that holds out of liquid capital for enterprise and investment.

"In 1850 the annual per capita earnings in America were $100. By 1890 they had increased to $200; and thirty years later, in 1920, they had increased to $600.

"The United States has created by 300 years of national history a national wealth of $300,000,000,000, while its nearest rival, England, with 2,000 years of productive industry, has reached $105,000,000,000.

"Volume of factory production in this country in twenty years, from 1900 to 1920, by the census figures, increased 95 per cent.

"In the decade which we measured from 1913 to 1922, in agriculture, we expanded our cereal production from 4,500,000,000 to 5,250,000,000 bushels; and at the same time the census was writing the record of 1,700,000 fewer workers in agriculture in 1920 than in 1900—1,700,000 fewer workers but an aggregate production increase of all our standard crops greater by 20, 30 and 40 per cent.

"The progress made in the automobile industry, based on economy of human effort, is shown in that in 1909 the output was 1.6 cars per worker, and in 1919, 4.1 cars per worker employed in the industry. The capital investment per car was $1,400 and now $1,100.

"Economy in workers, economy in capital investment—these are the signs of efficiency, of national progress and national prosperity on a secure basis, and they are repeated through all of the typical American industries. In the steel industry, to point for a moment—pig iron, which amounted to a production in 1889 of 267 tons per worker, increased in 1919 to 709 tons per worker.

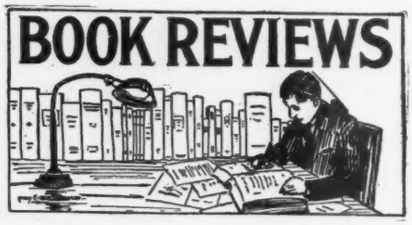
"The railroad car of 1875 was 65 per cent. dead weight and 35 per cent. running load, while today they have developed special types of cars that are 20 per cent. dead weight and 80 per cent. running load.

"The assurance of America's prosperity rests on the fact that the aggregate peak figures of production in March exceeded the peak of 1920; but the security of industry and safety rests on the fact that the index of wholesale prices for March is 35 per cent. below the peak of 1920, from which we had a disastrous deflation."

The annual convention of the American Mining Congress will be held this year at Milwaukee, Wis., from September 24 to 29, inclusive, and it is said that the organization will present at that time the most constructive platform ever offered the mining industry. A new feature of the convention will be practical discussions on machinery and materials used in mining. Manufacturers exhibiting products at the national exposition of mines and mine equipment are requested to send engineers to participate in these discussions; and mining men are invited to submit questions on mine equipment for consideration.

When a commercial traveler goes to Latin America he should take his dress suit and frock coat with him, according to Ernst B. Filsinger in the latest edition of the *Commercial Traveler's Guide to Latin America*. The social amenities are strictly observed even in business by our southern neighbors, and the proper clothes are, therefore, indispensable in promoting cordial trade relations.

SHUVELODER is the title of a booklet issued by the Lake Superior Loader Company of Duluth, Minn. Contractors and others interested in the subject of mechanical mucking will find this brochure of possible value to them. The Shuveloder has been developed to reduce mucking costs, to increase drifting and tunneling speeds, and to save in labor turnover by making it practicable for fewer men to do a given job.



AMERICAN PETROLEUM REFINING by H. S. Bell, C. E., Member of the American Petroleum Institute. A book of 456 pages with 263 illustrations. Published by D. Van Nostrand Company, New York. Price $5.00.

THE inspiration for this book has been the lack heretofore, among the literature dealing with the petroleum industry, of any work devoted exclusively to the presentation of information and data such as is especially desired by the refiner. The author has studiously sought to make good this deficiency. His purpose has been to include in his book the fundamental facts essential to the owner, the manager, or the engineer, who may be contemplating installations of refinery equipment, and, likewise, helpful to the employee seeking knowledge beyond the scope of his present experience.

As we are told, until recent years, little attention has been given to efficiency in oil refining; and the writer has aimed to furnish information and to offer suggestions which he believes will encourage further efforts to improve conditions as they now exist in many refineries. Certainly the subject of petroleum, and its skilful adaptation to the many needs of industry and modern life, is a matter that concerns well-nigh everyone today; and any treatise that will help to increase the economical utilization of our diminishing resources of crude oil should be welcome.

WHO'S WHO IN ENGINEERING, a biographical dictionary of contemporaries, 1922-23, by John William Leonard. A volume of 1,509 pages, published by John W. Leonard Corporation, New York. Price $10.00.

THIS IS the first edition of a biennial reference book which is likely to become the recognized standard biographical dictionary of contemporaries in the engineering profession. More than ever we have come to recognize of late the part the engineer has taken and is now playing in the onward march of the world. Mr. Leonard tells us what 10,500 of the profession have achieved—in short, tells concisely the life stories of all of these men so that each can be evaluated according to his record or chosen for leadership in the execution of some contemplated task. This reference book fills a special niche in the biographical field.

FUNDAMENTALS OF RECTIFICATION, by C. C. Van Nuys, Chief Physicist, Air Reduction Company, New York City.

THIS is a reprint of a paper which appeared serially in *Chemical and Metallurgical Engineering* during January and February of the current year. To persons interested in the rectification of liquefied gases, especially in the higher mathematics of this somewhat involved subject, Mr. Van Nuys' fairly exhaustive presentation will be found of much value.

HOW TO USE THE DICTIONARY, by Martin C. Flaherty, Professor of Forensics, University of California. A work of 108 pages, published by The Ronald Press Company, New York. Price $1.25.

MOST of us have grown to take the dictionary as a matter of fact, a sort of necessary evil, because it is inconvenient to carry around tucked in our heads more than a few hundred words about the meanings of which we can be reasonably certain. And when we have had to turn to the dictionary for guidance we have usually obtained only a meager measure of the information to be had about the words we have looked for.

Professor Flaherty says: "It is almost inconceivable that an authoritative work of reference so extensive in its scope, so varied in its contents as the dictionary, should be all but unknown to the great run of students and readers. Yet that this is the fact admits of not the slightest doubt." Continuing, "However startling it may appear to outsiders, it is pretty generally conceded among college instructors of English that not one in 50 of the graduates of our high schools has any critical judgment of the worth of our standard dictionaries, or can even interpret intelligently the data which these works lay before him."

In these days of publicity, when business interests of all sorts seek to win customers and to make sales through descriptive pamphlets, catalogues, etc., it is of the utmost importance that the information to be imparted should be told in a thoroughly lucid manner by the employment of the right words properly arranged. This gift of expression can be acquired to a goodly extent by an intelligent and frequent use of the dictionary.

PRACTICAL FACTS ABOUT BELTING is the title of a publication which has appeared recently, and which has been bound in a manner to make it serviceable to the man that really has to do with belting in its varied applications. The work is a handy manual on belting and power transmission such as would appeal to engineers, plant executives, production managers, maintenance men, factory superintendents, foremen, and purchasing agents. The volume is based upon the ripe experience of a company which has been engaged in this branch of industry for 55 years.

NEW MINING PUBLICATIONS

THE BUREAU OF MINES, of the Department of the Interior, has published the following new bulletins and technical papers:

BULLETIN 211. The chloride-volatilization process of ore treatment, by Thomas Varley, E. P. Barrett, C. C. Stevenson, and R. H. Bradford, with an introductory chapter by Stuart Croasdale. 1923. 99 pp., 7 pls., 5 figs.

BULLETIN 213. Talc and soapstone; their mining, milling, and utilization, by Raymond B. Ladoo. 1923. 133 pp., 15 pls., 23 figs.

BULLETIN 217. Preparation, transportation, and combustion of powdered coal, by John Blizard. 1923. 127 pp., 4 pls., 38 figs.

TECHNICAL PAPER 287. Preparation of light aluminum-copper casting alloys, by R. J. Anderson. 1922. 44 pp., 6 pls., 1 fig.

TECHNICAL PAPER 300. The universal and the fireman's gas mask, by S. H. Katz, J. J. Bloomfield, and A. C. Fieldner. 1923. 22 pp., 1 pl., 6 figs.

TECHNICAL PAPER 301. Proposed method for reducing mineral waste in the Wisconsin zinc district, by W. H. Coghill and C. O. Anderson. 1923. 64 pp.

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MOUNTING LOCOMOTIVE AND CAR WHEELS

By P. H. GRANT

TO THE average person who gives thought to such work as the mounting of cast-iron or steel locomotive and car wheels on hydraulic presses it might seem rough work, but such is not the case. As a matter of fact, it takes a machinist a considerable length of time to acquire sufficient skill and knowledge to become a first-class wheel borer or axle turner.

The machinist first measures a set of axles which are to have the wheels bored to fit them; he then writes the decimals down on a piece of paper; and, next, proceeds with the lifting of the wheel from the floor by means of a horizontal air hoist—the air, at about 100 pounds pressure per square inch, being supplied by an Ingersoll-Rand compressor. With these things done, the wheel is placed on the boring mill; the roughing cutters are set; and the cut is started. Right here is where the utmost skill and care must be exercised, as it is necessary for the machinist to ascertain the quality of the metal to be bored in order that he may be able to set the finishing cutters to the correct size and use the proper mounting pressure.

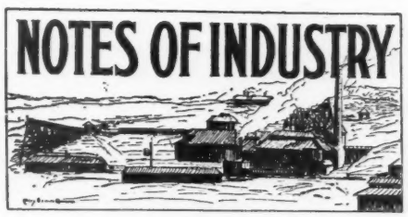
The question is, how can a man tell if a wheel is hard, medium, or soft? Let us try to explain this; but, even so, there is a certain indescribable something that must be sensed. The machinist examines the chips as they fall from the cutters; he feels the vibration of the boring machine and listens to the sound of it; and then he evaluates all these by that "something" that experience has taught him and which enables him to bore a wheel so that it can be forced on the axle by a pressure that is within prescribed limits.

It takes approximately one minute for the roughing cutters to go through the wheel; and in this short period of time the machinist must judge the toughness and the hardness of the metal in the wheel that is being bored. It is a well-known fact that in casting wheels the texture of the metal is not uniform, and for this reason the boring of wheels requires exceptional skill.

A novice will say that the job of boring wheels is easy enough after you have bored one to the proper allowance, but in that he is mistaken. When the finishing cutters have completed the bore the wheel is countersunk, whereupon it is lifted by the air hoist and put upon the floor. The average time consumed for the whole operation from floor to floor is about 3½ minutes.

The axle on which the wheel is to be pressed is raised to the desired height by a vertical air hoist; the wheel is then rolled into position; the bore, together with the seat on the axle, is lubricated; and pressure is started. The machinist has in the meantime put another wheel on the boring mill, and is hoping that this wheel will require the same pressure as the one on the press. As the axle is forced into the wheel the recording gage on the hydraulic press is marking down on a chart, in red ink, the exact pressure and the length of the pit.

After the axle has advanced the required distance, pressure is released; and if the press registers within the limits demanded and the second wheel has the same physical texture as the preceding one then the machinist knows that he is quite safe in boring a hole of the same size in the second wheel. But, unfortunately, he has to be just as careful with this second wheel as he was with the first: not only must he ascertain the hardness of the metal, but his sense of touch, by aid of the micrometer, must enable him to work to one-half of one-thousandth of an inch inasmuch as this variation in the size of a hole may mean a pressure of several tons when the wheel is being mounted.



Since the last radio conference was held in March, 1922, the number of broadcasting stations has increased from 60 to 581; and it is estimated that anywhere from 1,500,000 to 2,500,000 receiving stations are in use.

More than 15,000,000 pounds of dynamite are used in the United States in the course of a year in getting out of the earth the materials necessary for the making of cement.

At Globe, Ariz., in a lime quarry of the Old Dominion Company, a tunnel was driven 60 feet into the vertical face at a point 112 feet below the surface. A charge of 19 tons of dynamite was placed in the cavity; and it is estimated that from 70,000 to 100,000 tons of rock was dislodged and suitably broken up by the blast.

We have it upon the authority of *Iron Age* that half a century ago the annual production of steel in the United States was less than the average daily production during March of the present year. The total tonnage of steel ingots and castings in 1872 was 143,954 gross tons. The production of ingots in March alone amounted to 146,500 gross tons a day.

There are only 10,000 motor cars in China as compared with 12,000,000 in the United States; but, even so, good roads are now recognized by the Chinese as a necessity.

Almost 90 per cent., or 1,005,210 cubic feet of the limestone quarried in the United States for building purposes in 1922 came from the State of Illinois.

To advertise a washing machine, and to attract the attention of the passers-by, a furniture store decided on a novel window display in the shape of a mass of soapsuds. The soapsuds were produced by forcing compressed air through liquid soap contained in the electric washing machine.

In Gothenburg, Sweden, there is a boiler which operates at a steam pressure of 1,500 pounds per square inch. The steam is formed in revolving tubes—the centrifugal force assuring the contact of the water with the hot shell, and thus avoids the complication of superheated bubbles.

There are 371,522 telephones in the London telephone district. To ensure freedom from breaks, all possible connections are soldered; and in one exchange alone this involved, it is said, the making of more than 2,000,000 such joints. In New York City the number of telephones is 1,010,056! The soldering statistics are not given.

On a recent voyage to Australia, *via* Cape Town, an Aberdeen liner was in wireless touch with land stations in Great Britain all the time—receiving 65,000 words of news, and averaging 738 words a day for the entire voyage.

The quantity of explosives sold in the United States during the calendar year 1922 was 16 per cent. greater than the amount purchased in 1921.

Sweden has probably made greater progress in electrifying rural districts than any other country. During the 5-year period 1917-1921 the electrification of farmlands increased there from 6.4 to 38.5 per cent.

It has been estimated that more than half of the consumption of sulphur is in the manufacture of sulphuric acid, which seems incredible when we remember its other extensive uses. Large quantities are employed in the sulphite process of digesting wood for paper. In agriculture it is used as a fungicide for grapes and hops, and as a fertilizer, insecticide, fumigant, and sheep dip. The vulcanization of rubber, the manufacture of matches, explosives, dyes, and cements, and also photography and medicine all draw heavily on the supply.

The supply of natural gas in Cleveland is so precarious, with the not remote prospect of complete failure, that F. W. Ballard, public utility engineer, urges the city to proceed with plans for an artificial gas plant at mines near Akron, 60 miles away, and high-pressure transmission from there to Cleveland. The distance would be only about one-half that of the natural-gas transmission of the East Ohio Gas Company, which pumps its gas from West Virginia.

FUEL AND POTASH FROM LOW-GRADE MOLASSES

BEET-SUGAR producers in the West and growers of sugar cane in the South may, in the future, utilize the crude molasses derived from their respective products as a fuel in their homes and as a fertilizer in cultivating their crops. Or, putting it in a different way, a portion of the sweetening obtained from sugar beets and sugar cane of one harvest may be devoted to enriching the soil as a means of increasing the yields of subsequent crops. The transforming process, other than having the semblance of a ring within a ring, appears visionary when one weighs the proposal to convert low-grade or blackstrap molasses into a liquid fuel and then to change its residue into potash.

The success of this chemical and mechanical process, however, is an accomplished fact. Dr. Paul G. Hildebrand, chemical and mechanical engineer of Swarthmore College, Pa., has been granted basic patents in the United States and abroad on his method for treating molasses so as to render it suitable for consumption as fuel and at the same time to recover potash as a by-product. At the research laboratory of Swarthmore College the virtue of this remarkable invention has been demonstrated; and from each ton of low-grade molasses subjected to the process is obtained a fuel, having a heating value equivalent to a ton of coal, and 150 pounds of commercial potash.

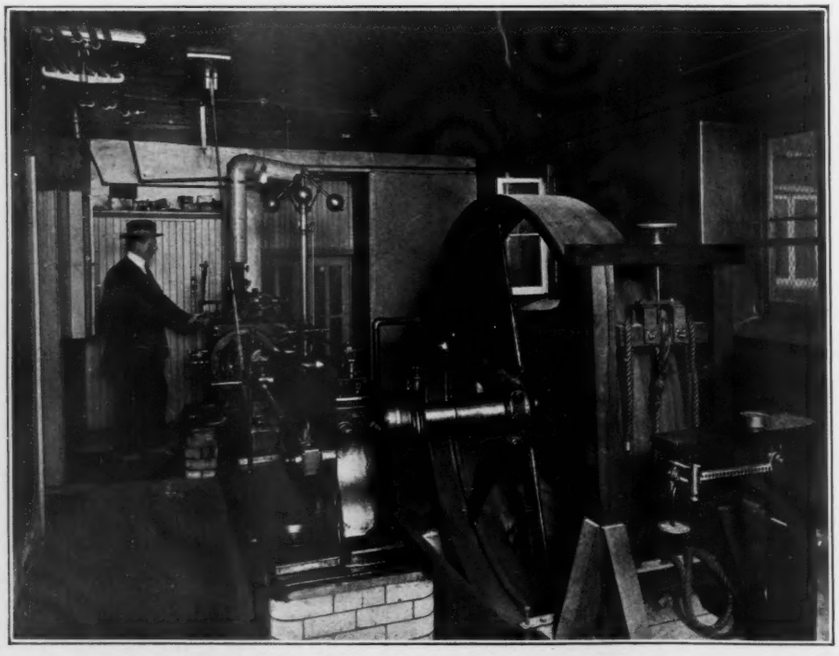
At present, crude molasses from sugar refineries is considered a waste product. Cuba and other big sugar-producing countries have dumped this inferior form of sweetening on us until anti-dumping legislation put a ban on the practice. Cuba, alone, produces yearly 1,000,000 gallons of blackstrap molasses, which is looked upon as waste by sugar planters. By the Hildebrandt process, this 1,000,000 gallons of molasses becomes equivalent to 4,000 tons of coal and 600,000 pounds of commercial potash. The significance of this conversion may be visualized when it is known that Cuba and other Latin-American sugar-producing countries have no coal mines or oil wells. Obviously, their supplies of fuel must be imported —a factor that cannot be ignored in any cost-accounting system.

The experimental plant, at Swarthmore College, employed by Doctor Hildebrandt in producing commercial potash and a liquid fuel from low-grade molasses.

Doctor Hildebrandt's invention capitalizes a waste and makes it available for fuel to sugar refineries whose coal and oil demands are increasingly large. Further, potash is an agricultural necessity, and any process that may lessen our dependence on foreign sources of this plant food certainly merits investigation. The Hildebrandt discovery, according to claims, offers a method for the practical production of potash in quantity lots within our own confines.

There are 5,000 raw-sugar factories in the world, according to a recent estimate. The small producing units yield an output of 1,000,000 gallons of inferior molasses—a veritable waste at the source of supply—within a single cane-grinding season, embracing from 60 to 150 days. Any one of these sugar factories may expend each year from $50,000 to $60,000 for fuel and from $75,000 to $100,000 for commercial potash for fertilizing purposes. The investment for both fuel and potash is likely to amount to $150,000. But, if the Hildebrandt process be utilized, the following results may be expected: 1,000,000 tons of crude molasses, when converted into a fuel equal to coal selling at $15 a ton, represents a saving of $15,000,000. The production of 75,000 tons of potash, a by-product of the fuel, valued, say, at $100 a ton, adds $7,500,000, a total saving of $22,500,000.

Low-grade or blackstrap molasses, after being subjected to treatment according to the formula of this process, will burn much like fuel oil. It is productive of an intensive heat and, when appraised in scientific terms, has a heating capacity of 13,000 B. T. U's. Tests at Swarthmore College have indicated that this form of liquid fuel could operate a large steam engine, which, in turn, could drive a dynamo capable of supplying electric current. Subsequently, the experimental machinery was removed to New York City, where improvements were made on it. A demonstration of the process is said to have elicited the approval of the Chemical Foundation of America.



Engine operated by steam generated by liquid fuel obtained from molasses. Dr. Paul G. Hildebrandt, the inventor, has his hand on the throttle.

The United States Government has the largest lighthouse organization in the world. It now maintains 16,373 aids to navigation, and has 117 vessels, including lightships, in commission.